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Louisiana Bulletin No. 171 *July, 1920*

Agricultural Experiment Station

OF THE

LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE

BATON ROUGE, LOUISIANA

THE AMOUNT OF SALT IN IRRIGATION WATER INJURIOUS TO RICE.

BY

*F. C. QUEREAU,
Asst. Director Rice Experiment Station

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*Resigned

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THE AMOUNT OF SALT IN IRRIGATION WATER INJURIOUS TO RICE.

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BY

F. C. QUEREAU.

An extreme drought during the irrigating season in the rice belt does not occur frequently. When such does happen, however, certain streams which normally supply an abundance of fresh water for large rice acreage may become brackish and thus injurious to rice. The season of 1917 was such a one. The water in many of the large streams became brackish in June. Later in the season the amount of salt per gallon ranged from 10 to 500 grains.

It is commonly believed by the rice farmers and canal men that not more than 35 grains per gallon should be used on rice. Information on the amount of salt rice will withstand is not available. The following are some of the inquiries that would arise under conditions experienced during 1917.

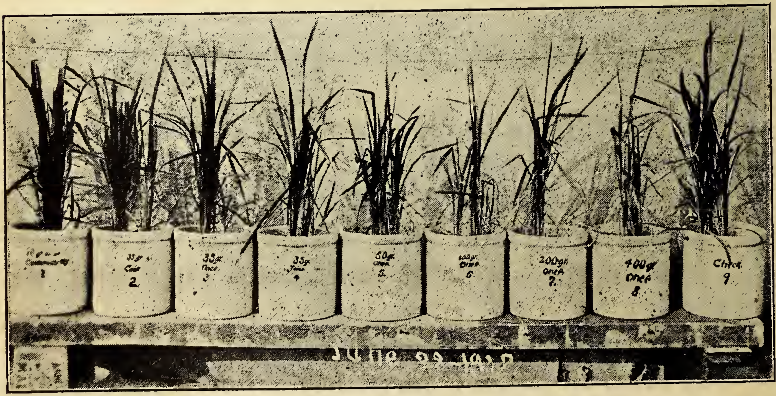
1. If the ground is wet but not flooded with fresh water will one six-inch flooding with water containing 35 grains of salt per gallon be injurious if same be followed by fresh water?
2. Will two floodings of 35 grains per gallon be injurious?
3. Will continuous flooding with 35 grains per gallon be injurious?
4. Will a flooding of 50 grains per gallon be injurious?
5. Will a flooding of 100 grains per gallon be injurious?
6. What effect will salt have on the grain when matured?
7. What will be the effect on the soil?

In order to secure more authentic information on this subject the following experiment was established.

298040

The rice at the beginning of the experiment, June 15.

Growing rice from the field was placed in nine two-gallon earthernware jars. When placed in the jars the rice was about eighteen inches high. The plugs of earth containing the rice plant roots were carefully cut so that they fitted the jars exactly. The rice roots were not disturbed. The variety was Experiment Station Selection No. 2010, called Brazla, an early rice of the long grain type similar in growing period and type of grain to Honduras. The land was absolutely dry at the time of transplanting. There was room in the jars for three inches of irrigation water. The rice was placed in the jars June 12 and flooded



June 28. Note that 100, 200 and 400 grain applications are beginning to show the effect of the salt.

for two days with fresh water. June 15 the fresh water was drained off, leaving the soil wet, and the salt solutions to be used in the experiment were applied. The salt solutions were prepared and applied by Otto Jaschke, chemist in charge of the Kaplan Laboratory in Crowley.

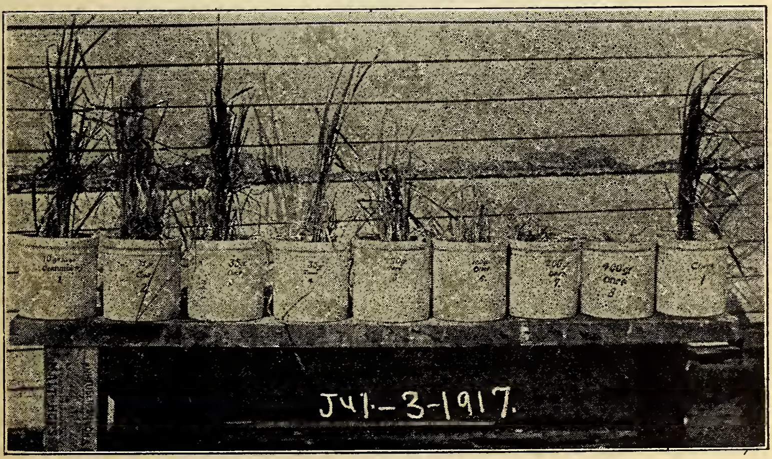
Following is an outline of the experiments with notes on same from June 15 to the end of the experiment.

Pot No. 1. All of the irrigation water used in this experiment contained ten grains of salt per gallon. There was no observable effect on the rice.

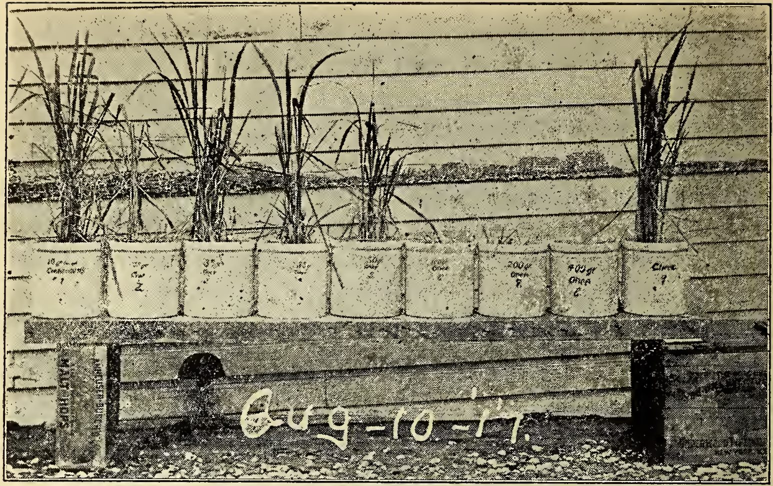
Pot No. 2. All of the water used in this experiment contained 35 grains per gallon. About 40 acre-inches were applied. By July 1 the effect of the salt could be observed. August 15 the rice was not over half the size of the check. By September 10 the rice was entirely dead. The check (No. 9) and No. 1 produced good heads.

Pot No. 3. By June 20 six inches of water had been applied containing 35 grains of salt per gallon followed by subsequent irrigations of fresh water. The effect of the salt could not be observed. The heads and grains seemed normal.

Pot No. 4. By July 3 this pot received 12 acre-inches of water or two six-inch irrigations of water containing 35



July 3. All of the rice that received above 35 grains of salt (Pot 3) is badly injured; from 100 to 400 grain applications, dead.



August 10. Note that the rice in Pots 4 and 5 is beginning to recover because of the fresh water.

grains of salt per gallon. After this fresh water was used. Early in July the effect of the salt could be observed to a limited degree. In this pot the rice was injured to a considerable extent. It is estimated that rice of this kind would produce about half a crop. In this case the salt seemed to delay the heading. The heads were badly filled and the grains light.

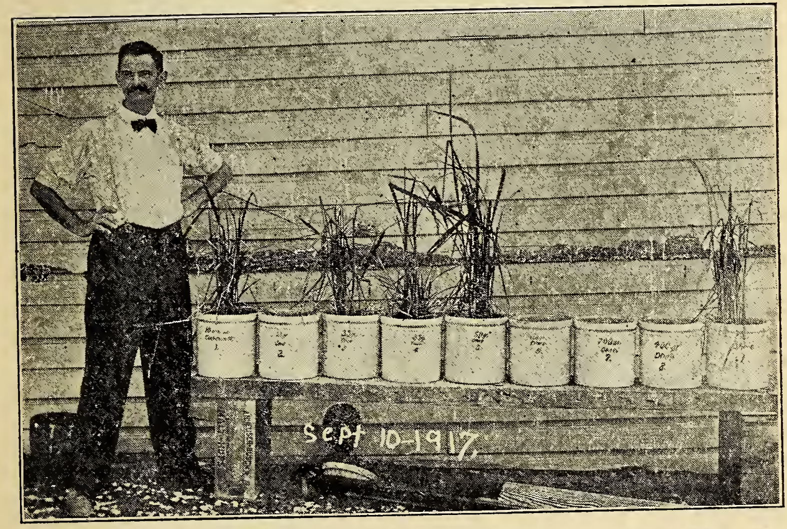
Pot No. 5. This experiment received one six-inch flooding of water containing 50 grains of salt per gallon followed by fresh water. By June 28 the effect of the salt could be easily observed and two weeks later the plants had the appearance of being half dead. After the fresh water was put on, the rice seemed to recover. It is believed that a crop of this kind of rice would be about 25 per cent short.

Pot No. 6. By June 20 this pot had received 6 acre-inches of water containing 100 grains of salt per gallon. By June 28 the effect of the salt was easy to observe. By July 25 the plants of this experiment were completely dead. Fresh water was applied after June 20.

Pot No. 7. By June 20 this experiment had received 6 acre-inches of water containing 200 grains of salt per gallon. The effect of the salt could be observed in ten days from the time of application and by July 12 the plants were completely dead.

Pot No. 8. By June 20 this experiment had received six acre-inches of water containing 400 grains per gallon. After this fresh water was applied. By July 1 all the plants of this experiment were completely dead.

Pot No. 9. Check pot received fresh water as required and commenced to head August 15. The rice seemed normal in every way.



September 10. Note that 35 grains continuous flooding (Pot 2) is dead. 35 grains once, 35 grains twice, and 50 grains once (Pots 3, 4, and 5 respectively) are about equal in size and quality of grain. All three are as good in size but not in quality of grain as the check pot (No. 9). Compare Pot 5 in this cut with Pot 5 in cut of July 3.

EXPERIMENT UNDER FIELD CONDITIONS

AT ESTHERWOOD, LA.,

By Jaschke and Hoffpauir.

In a field of Blue Rose rice near Estherwood, La., five plots were established. The plots were 5 by 10 feet square and surrounded by a good substantial levee. The land was flooded with fresh water when the plot levees were constructed. The plots were drained and the tested solutions of salt water applied as indicated in the table. The water was obtained from a nearby well. The solutions were mixed in barrels and applied to the land with buckets. The plots were flooded with the solutions about three inches deep through the entire growing season. Following is all of the data in connection with the plots.

	PLOT 1	PLOT 2	PLOT 3	PLOT 4
Grs. Salt per Gal. Water Used	25	35	50	75
July 28—Irrigation, Gallons Used	250 Gal.	250 Gal.	250 Gal.	250 Gal.
July 31, 2nd Irrigation	200 Gal.	200 Gal.	200 Gal.	200 Gal.
August 2, 3rd Irrigation	100 Gal.	100 Gal.	100 Gal.	100 Gal.
August 9, 4th Irrigation	100 Gal.	150 Gal.	150 Gal.	150 Gal.
August 15, 5th Irrigation	150 Gal.	200 Gal.	200 Gal.	200 Gal.
August 28, 6th Irrigation	100 Gal.	100 Gal.	100 Gal.	100 Gal.
September 11, 7th Irrigation	100 Gal.	100 Gal.	100 Gal.	100 Gal.
September 20, 8th Irrigation	200 Gal.	200 Gal.	200 Gal.	200 Gal.
September 29, 9th Irrigation	200 Gal.	200 Gal.	200 Gal.	200 Gal.
Salt Applied per Acre.	4224 lbs.	6600 lbs.	9427 lbs.	14080 lbs.
Yield of Rice per Acre.	3049 lbs. (18.8 bbl.)	2450 lbs. (15.1 bbl.)	1524 lbs. (9.4 bbl.)	1143 lbs. 7.05 bbl.)
Quality of Grain.	Good	Fair	Bad	Bad
Pounds per Bushel—Cup Test.	42	40	41	37

Ripe rice in plot 1 of the Estherwood field experiment. Irrigated with water containing 25 grains of salt per gallon.

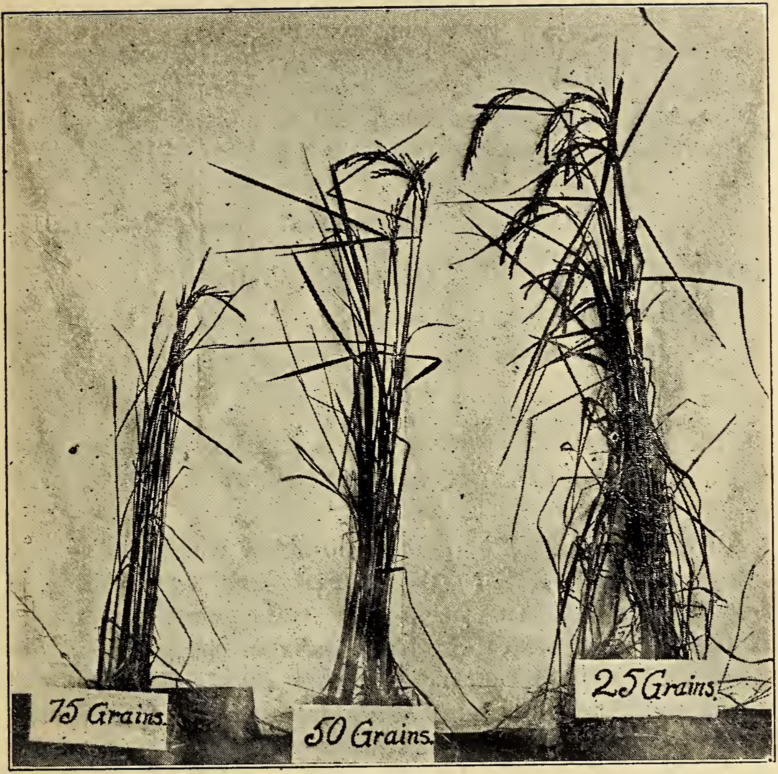
The data on plot 5 is considered of no value and is not given in this table. It was found that clay from the well had been at one time thrown on this plot which prevented seepage in the same degree as the others; as a result less water was required to keep this plot flooded. Again because of the clay the salt solution did not gain access to the roots as readily as on the other plots. The solution used on plot 5 contained 100 grains of salt per gallon; yet at the end of the test not as much salt had been used as on the other plots. This may perhaps indicate that on very heavy clay land more salt can be used without injury than on the lighter soils.

In comparing the pot experiment with the field experiment at Estherwood attention is invited to the fact that in the pots there could be no seepage and no loss of water other than the evaporation. No rain was permitted to fall on the pots. In the field experiment there was a certain amount of levee seepage and soil percolation. During July and August several small rains fell on the plots. The rains were unusually light for the season probably amounting to one or two acre-inches. (Station record of precipitation could not be used in this case because it is known that several more inches of rain fell at the station during this period than at Estherwood.) It is believed that the pot experiment is a good indication as to the amount of salt that rice will withstand, but that it does not represent field conditions with reference to seepage, percolation, and rainfall.

In all observations made by the writer the quality of the grain was found to be affected in rice produced in salt solutions where the amount of salt per gallon was 35 grains or more. The sample of rice raised in plots 3 and 4 of the Estherwood experiment was decidedly bad. The grains were in many cases light and twisted. The rice was soft and chalky. In a sample of this kind the percent of head rice in the mill must necessarily be very low.

A great many contradictory reports were received during the season with reference to salt-water damage. There were many reports of good crops raised with as much as 100 grains per gallon of salt. Unfortunately, all of these

Ripe rice in plot 4 of the Estherwood field experiment. Irrigated with water containing 75 grains per gallon. See table of yields. The quality of the grain is very poor.



Typical Plants from Plots 1, 3, and 4 from right to left.
Estherwood Field Experiment.

reports could not be investigated. Of those on which the true data was secured the following is a fair sample.

A farmer, living near Abbeville, La., stated that he raised a good crop of rice with water that ranged from 100 to 150 grains of salt per gallon. It was found that 40 acres of Japan and Honduras rice having a certain amount of fresh water on same at initial irrigation with salt was irrigated as stated, but that the salt water was run over the fields and drained out on the lower side. The average yield per acre in this case was found to be about four bags. The quality of the rice from the lower part of the field was very poor.

On the other hand we have the statement of Mr. J. E. Broussard, president of the Beaumont Rice Mills and one of the largest growers of rice in Texas, that good rice can be produced with water containing 50 or more grains of salt per gallon. Mr. Broussard's letter is published herewith.

"Beaumont, Texas, Nov. 2, 1917.

"Mr. F. C. Quereau, Asst. Director in Charge,
Rice Experiment Station,
Crowley, La.

"Dear Sir:

I have yours of the 30th and note that you will soon publish a tabulation of experiments on salt water for rice irrigation, and I have the following:

First—One field of about 400 acres belonging to me, being practically all black hog wallow land, was planted in rice and the first irrigation was made about the middle of June with water containing 35 grains per gallon at the start, and we finished irrigating at that time when the water contained 55 grains per gallon. From that on the land was irrigated three or four times and at no time did the water contain less than 35 grains, and the last part of each irrigation period the water contained as much as 55 grains. After this the land was irrigated three or four times. We commenced pumping when the water contained 35 grains and stopped pumping when it reached 55 grains. This rice made a very good yield; some of it making as much as 15 bags per acre, while other portions of it where the water was very shallow and the same was only irrigated a couple of times made about 5 sacks. The entire field will average between 10 and 11 sacks and the rice is of excellent quality, all Blue Rose.

"Second—This was irrigated about the first of June with fresh water, but the water became salty about July 1 and no water was used until about the middle of July or later when we began irrigating with water containing 100 grains per gallon. Most of the fields were irrigated with this water though a large portion of it was watered at this time with water containing 150 grains. The next water was along about the middle to the last of August when water containing 150 grains per gallon was used. The rice is now being threshed and some fields are making as much as 10 to 11 bags per acre while others will not make more than five or six. It seems that where the water was used on the side hills and was dry a large portion of the time that the rice will make very poorly, but where the water stood in the fields most of the time the rice is giving very good yields. A portion of this crop is Honduras and a portion Blue Rose. The Blue Rose seems to stand the salt water better than the Honduras.

"Very truly yours,
The Beaumont Rice Mills,
J. E. Broussard."

It may be of interest to the rice farmer to know the amount of salt applied to the land through the use of salt water of different concentrations. Rice requires on an average of from 45 to 60 acre-inches of water. During a season similar to that of 1917, giving consideration to the leakage of the levees, drainage at harvest, and one or two irrigations of fresh water prior to the application of salt water, the amount of brackish water which under ordinary conditions is added to fresh water already in the field from previous irrigations will seldom exceed 30 acre-inches out of a possible total of 60 acre-inches for the entire crop.

(1) 27,154 gallons are required to flood 1 acre 1 inch deep. If the water contains 35 grains per gallon of salt (7,000 grains per pound), then the above acre-inch will if it evaporates on the field apply to the soil 135.6 pounds of salt. Thirty acre-inches will apply 4,068 pounds of salt.

(2) If the water contains 25 grains of salt per gallon, 1 acre-inch will apply 96.9 pounds of salt, and 30 acre-inches will apply 2,907 pounds.

(3) If the water contains 50 grains per gallon, 1 acre-inch will apply 193.9 pounds of salt, and 30 acre inches will apply 5,817 pounds.

(4) If the water contains 100 grains per gallon, 1 acre-inch will apply 387.9 pounds of salt and 30 acre-inches will apply 11,637 pounds per acre.

1 acre-inch of water is equal to 6,272,640 cubic inches. A gallon contains 231 cubic inches. 7,000 grains troy is equal to 1 pound avoirdupois.

The above may be of value to the farmer in making calculations which will be of service to him when using irrigation water containing salt.

From the data at hand it would seem safe to make the following suggestions with reference to the use of brackish water on rice.

(1) Do not use more than 35 grains per gallon of salt in a flooding of from 4 to 8 inches if this amount of salt water is to remain on the field until it evaporates or is diluted with fresh water.

(2) Do not flood a second time with water containing more than 15 grains of salt per gallon.

(3) It may or may not be harmful to use water containing 50 grains of salt on land which is wet prior to the application of the salt water, when it is possible to remove all of the salt water and replace with fresh water within two weeks of the time that the salt is applied.

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Agricultural Experiment Station

of the

Louisiana State University and
A. & M. College

Baton Rouge

RICE INVESTIGATIONS

*F. C. QUEREAU,
Asst. Director,
RICE EXPERIMENT STATION.

Baton Rouge
GLADNEY'S PRINT SHOP
1920

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*Resigned Feb. 1918

RICE INVESTIGATIONS

BY

FRIEND C. QUEREAU
ASST. DIRECTOR

RICE EXPERIMENT STATION
CROWLEY, LA.

THE RICE EXPERIMENT STATION.

The Coastal Plain area of Southwest Louisiana came into special prominence as a rice producing section about 1896. The maximum production of this area was reached about 1905. Following this there was a decline in the average yield per acre for several years. This created a demand on the part of the rice farmer for scientific investigations along the lines of seed improvement, soil fertility, insect pests, noxious weeds, irrigation requirements, rice diseases, crop rotation, and cultural methods. In 1904 a bulletin was published by W. R. Dodson, W. C. Stubbs, and C. A. Browne, known as Louisiana Bulletin No. 77 on *Rice*. This is the latest bulletin published on rice by the Louisiana Station. Because of the fact that Bulletin No. 77 is at present out of print and because a large part of the information contained therein would be of service to the rice industry of Louisiana to-day, extracts from it will be used in this publication and a portion of it will be used verbatim.

In order to meet the demand for information on rice the Office of Cereal Investigations of the United States Bureau of Plant Industry conducted a number of cooperative experiments in various places in the rice growing sections of Louisiana and Texas. Experiments under the direction of M. A. Carelton, of the United States Department of Agriculture, and W. R. Dodson, of the Louisiana Station were conducted for two years on the Shoemaker Farm near Crowley. A large number of varieties of rice which had been collected from the four corners of the earth by the Department agents were propagated, and the results from them were so promising that the Office of Cereal Investigation decided to give rice a permanent place in this office. C. E. Chambliss was appointed agronomist in charge of rice investigation in 1908. The United States Department was seeking a desirable location for its rice work. The Louisiana Experiment Station decided that rice should be given especial consideration in the Station work for the reason that a large portion of the state is peculiarly adapted to rice culture. Again it is believed that rice should receive some consideration for the reason that it would make certain level prairie areas, which under ordinary conditions is a cattle range, having a value of only a few dollars per acre, a prosperous rice farming country. It was, therefore, decided to invite the cooperation of the United States Department of Agriculture and establish an experiment station in South Louisiana which would devote its efforts largely toward the problems of rice culture. In a plan of this kind there is advantage to the State on the one hand of the vast scientific machinery of the Federal Departments, opportunity of securing seed and plants from all over the world, and eliminating the chance of useless duplication of experiments; and on the other hand such an arrangement would be advantageous to the Department because of the facilities provided by the State for carrying on experiments covering a long period of time and for closer contact with the people they are serving.

A satisfactory agreement was entered into and the Rice Experiment Station was established at Crowley, Acadia Parish, La., in 1909. In this agreement the State is to have control of the experiments pertaining to fertilizer, soil fertility, rotation of crops, red rice, and weed eradication, and irrigation. The Bureau of Plant Industry is to conduct all experiments in seed-rice propagation, plant diseases, insects, and certain irrigation experiments. Various problems which developed as the work proceeded were handled cooperatively or by the department having the facilities for best doing the work. J. M. Jenkins, assistant agronomist, has charge of the work for the Bureau of Plant Industry at the Rice Station; and F. C. Quereau, assistant director in charge under Director W. R. Dodson, directs the work for the State. The following facts in connection with the Rice Station will be of interest to the rice farmer and may make more comprehensive the data hereinafter presented.

The Rice Station is located one mile west of the federal building of the City of Crowley on the interstate highway, known as the Spanish Trail. The farm contains 60 acres.

Soil and previous conditions: The soil is Crowley silt loam underlaid with a heavy yellow clay. The grey silt top soil is from two to three and one-half inches deep. The soil is typical of the rice belt but is not as good as the average rice soil of Acadia Parish, which is from 3 to 10 inches deep. The land was continuously cultivated to rice for possibly 15 years previous to the purchase by the Experiment Station. The land was so badly infested with red rice and weeds that in many places on the farm white rice could not be grown. Red rice seed was mixed with the soil five inches or more below the surface, or as deep as the land had ever been plowed. The first problem was that of eradicating the red rice and other weeds. This was accomplished by cultivated crops and, where necessary, by hand methods. It was several years before the red rice could be completely controlled.

How laid out: The farm was laid out in plots ranging in size from one-eighth acre to one acre. The greater number of the plots were leveed. Irrigation canals and drainage ditches were constructed so that the land could be completely drained or irrigated at will.

Outline of experiments: About one-half of the farm was devoted to the work of the United States Bureau of Plant Industry which consists largely of the propagation of rice seed. A series of plots were established for experiments in the use of commercial fertilizer. Another series of plots were devoted to a system of crop rotations. Other plots were used for experiments with insects and plant diseases, and miscellaneous highland crops. There are no experiments with livestock in the Station.

Buildings: The buildings consist of a barn used for work animals and the storage of machinery, a shop with the necessary farm tools, a water system, a laboratory, and a residence for the assistant director. A mill for the experimental milling of rice has been arranged for.

It is the purpose of this bulletin to give information, based on the results of the experiments outlined, which will be of service to the rice farmer and aid him in improving his methods of farming.

The Rice Station receives many letters from people who have never had any experience in rice raising who desire elementary directions as to the operations necessary to produce a crop of rice. A part of this bulletin will be devoted to giving this information, which will be based on Station experiments and upon the observed results of successful rice farmers in the Rice Belt.

FERTILIZER EXPERIMENTS.

Object of the Experiments: To ascertain the effect of the various combinations of commercial fertilizer on rice land, which through the continuous cultivation of rice yields have become reduced to a point where the cultivation of rice is no longer profitable. The data desired is listed as follows:

1. The elements of plant food most desired, and the amount most profitable to be applied.

2. The combination of elements of plant food most required and the amount of same which will produce the most profitable results.

3. The length of time that rice can be grown on the same land without rest, or a change of crop, through the use of commercial fertilizers.

4. What will be the final effect on the soil through the employment of the methods outlined above.

These are the problems on which the farmers desire information and which these experiments propose to answer.

Soil: The soil selected for the commercial fertilizer experiments had been in continuous cultivation to rice for about 15 years. This land would, without fertilizer, produce from six to seven barrels of No. 5 Honduras rice. The grey top soil of these plots is fairly uniform as was ascertained by planting a crop of rice over the entire area in 1909. The top soil is about two inches deep. Beneath the grey soil is yellow clay sub-soil.

Outline of experiment: Nineteen plots were used for these experiments. Each has an area of one-quarter acre. The plots were separated by substantial levees. At one end of the range of plots is an irrigation canal and on the other side a deep drainage ditch. All of the plots could be either irrigated or drained, as the case might require, within ten hours. Conditions were made as uniform as possible with reference to planting, draining, fertilizing, and irrigating. When possible, any one of these operations was performed on all of the plots the same day. All conditions were made as uniform as possible.

Fertilizers: No proprietary formulas were used in these experiments for the reason that it is believed that it is more profitable for the farmer to purchase the materials necessary and mix them on the farm with farm labor. All of these experiments were conducted with the idea of home mixed formulas. It is the common practice of the fertilizer manufacturer to emphasize the idea of the formula. The farmer knows very little as to the character of the materials which make up the formula. For example; the average farmer has a very vague idea as to the meaning of "superphosphate", "Citrate soluble", and "reverted phosphate". These experiments are conducted with the idea of emphasizing the values of the materials which make up any formula rather than the formula and to encourage the purchase of the materials for home mixing when it is necessary to use more than one element.

All of the fertilizer used in these experiments was spread broadcast on the disced land previous to planting the seed. This was done for the reason that there is no machine on the market which will distribute commercial fertilizer in the seed row with the seed but not in contact with it. Fertilizer when used in as large amounts as is necessary in experiments of this kind should not be in contact with the seed for the reason that if the land is dry, there is danger of loss of stand. In farm practice, however, where conservative application of fertilizer is used and when the soil is not too dry, the combined seed and fertilizer drill is believed to be the better method. This will be fully discussed later. In these experiments large applications were made for the reason that information was desired as to maximum quantities that it is profitable to use. Again, large applications give quicker results in showing the effect of the firtilizer on the soil.

The fertilizers used are 16 per cent. phosphate, 12 per cent. German Kainit, and a good grade of cottonseed meal. As a source of nitrogen ammonium sulphate is probably better as a rice fertilizer than cottonseed meal, but at the time that these experiments were inaugurated was not as easily obtainable.

OUTLINE OF THE EXPERIMENTS.

This entire experiment was run seven years. Rice was planted each year. Each plot received the same amount of fertilizer each year during the entire period. The plots were planted the first year, 1910, to Honduras, 1911 to Shinriki, and the last five crops to Blue Rose. The plots were numbered as below and were given the applications of fertilizer indicated. The plots all have an area of one-fourth acre.

Plot 1. Two hundred pounds per acre of 16 per cent. acid phosphate.

Plot 2. Four hundred pounds per acre of 16 per cent. acid phosphate.

Plot 3. Six hundred pounds per acre of 16 per cent. acid phosphate.

Plot 4. Check plot—no fertilizer.

Plot 5. Two hundred pounds per acre of 12 per cent. German Kainit.

Plot 6. Four hundred pounds per acre of 12 per cent. German Kainit.

Plot 7. Six hundred pounds per acre of 12 per cent. German Kainit.

Plot 8. Two hundred pounds per acre of 16 per cent. acid phosphate and one hundred pounds of Kainit.

Plot 9. Phosphate four hundred pounds and Kanit two hundred pounds per acre.

Plot 10. Phosphate two hundred pounds and cottonseed meal two hundred pounds per acre.

Plot 11. Kainit two hundred pounds and cottonseed meal two hundred pounds.

Plot 12. Kainit four hundred pounds and cottonseed meal two hundred pounds.

Plot 13. Check plot, no fertilizer.

Plot 14. Stable manure, fifteen loads per acre, and four hundred pounds of phosphate, and one hundred and fifty pounds of Kainit.

Plot 15. Stable manure, fifteen loads per acre.

Plot 16. Phosphate two hundred pounds, Kainit two hundred pounds, and cottonseed meal two hundred pounds.

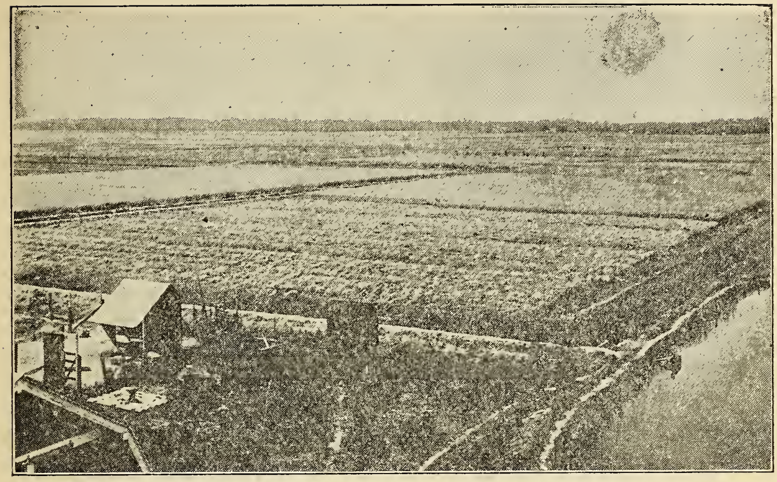
Plot 17. Phosphate four hundred pounds, Kainit four hundred pounds, and cottonseed meal two hundred pounds.

Plot 18. Phosphate six hundred pounds, Kainit six hundred pounds, and cottonseed meal three hundred pounds.

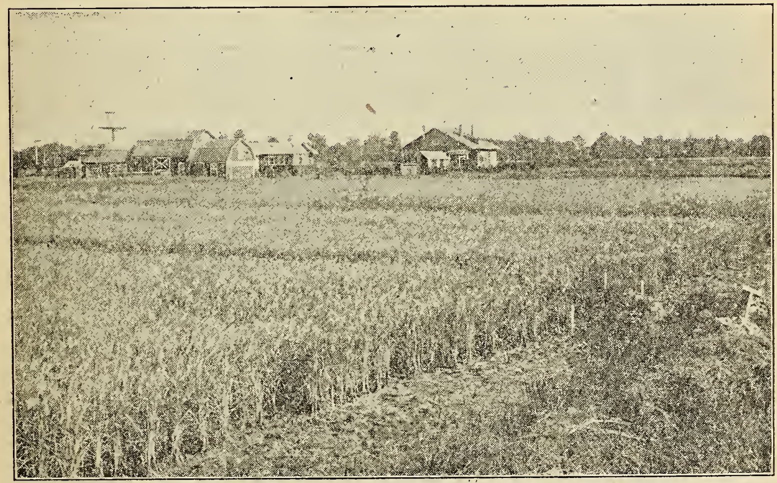
Following is a table giving condensed results of the experiment during the period, showing yields each year, variety of rice and cost of fertilizer:

TABLE No. 1.

PLOT	1	2	3	4	5	6	7	8
COST PER ACRE	$1.60	$3.20	$4.80		$1.25	$2.50	$3.75	$2.22
FERTILIZER POUNDS	Phosphate 200 lbs.	Phosphate 400 lbs.	Phosphate 600 lbs.	Check	Kainit 200 lbs.	Kainit 400 lbs.	Kainit 600 lbs.	Phos. 200 ℔ Kainit 100 ℔
1910 HONDURAS lbs. and bbls.	1,601 lbs. 10.50 bbls.	1,814 lbs. 11.20 bbls.	1,636 lbs. 10.10 bbls.	1,140 lbs. 7.10 bbls.	2,138 lbs. 13.2 bbls.	2,073 lbs. 12.8 bbls.	1,823 lbs. 11.26 bbls.	Red Rice 1,186 lbs. 7.33 bbls.
1911 SHINRIKI	1,798 lbs. 11.10 bbls.	2,025 lbs. 12.50 bbls.	1,539 lbs. 9.50 bbls.	1,636 lbs. 10.10 bbls.	1,652 lbs. 10.2 bbls.	1,668 lbs. 10.3 bbls.	1,117 lbs. 6.9 bbls.	Red Rice 819 lbs. 5.06 bbls.
1912 BLUE ROSE	4,584 lbs. 28.30 bbls.	3,612 lbs. 22.30 bbls.	3,447 lbs. 21.90 bbls.	2,711 lbs. 16.80 bbls.	2,859 lbs. 17.65 bbls.	2,851 lbs. 17.6 bbls.	2,593 lbs. 16.01 bbls.	2,858 lbs. 17.50 bbls.
1913 BLUE ROSE	2,540 lbs. 15.68 bbls.	2,463 lbs. 15.21 bbls.	2,609 lbs. 16.11 bbls.	2,468 lbs. 15.24 bbls.	2,708 lbs. 16.72 bbls.	2,484 lbs. 15.4 bbls.	2,676 lbs. 16.52 bbls.	1908 lbs. 11.78 bbls.
1914 BLUE ROSE	2,410 lbs. 14.88 bbls.	2,268 lbs. 14.00 bbls.	1,607 lbs. 9.92 bbls.	2,378 lbs. 14.68 bbls.	2,544 lbs. 15.77 bbls.	2,536 lbs. 15.66 bbls.	2,175 lbs. 13.43 bbls.	Grass 1,315 lbs. 8.12 bbls.
5 YR. AV. Lbs and bbls.	2,586 lbs. 15.9 bbls.	2,436 lbs. 15 bbls.	2,167 lbs. 13.3 bbls.	2,036 lbs. 12.5 bbls.	2,558 lbs. 15.7 bbls.	2,324 lbs. 14.35 bbls.	2,076 lbs. 12.82 bbls.	1,611 lbs. 9.95 bbls.
1915 BLUE ROSE	Grass 1,260 lbs. 7.78 bbls.	Grass 1,493 lbs. 9.22 bbls.	Grass 919 lbs. 7.53 bbls.	Clean 2,219 lbs. 13.7 bbls.	Clean 2,219 lbs. 13.7 bbls.	Clean 2,592 lbs. 16.0 bbls.	Clean 2,413 lbs. 14.9 bbls.	Grass 1,004 lbs. 6.20 bbls.
1916 BLUE ROSE	Grass 1,020 lbs. 6.30 bbls.	Grass 874 lbs. 5.4 bbls.	Grass 1,247 lbs. 7.70 bbls.	Clean 1,717 lbs. 10.60 bbls.	Clean 1,377 lbs. 8.5 bbls.	Clean 1,798 lbs. 1.11 bbls.	Clean 1,652 lbs. 10.2 bbls.	Grass 1,942 lbs. 11.99 bbls.
EXPERIMENT CLOSED 7 YR. AV.	2,173 lbs. 13.4 bbls.	2,078 lbs. 12.8 bbls.	1,858 lbs. 11.4 bbls.	2,038 lbs. 12.6 bbls.	2,238 lbs. 13.82 bbls.	2,287 lbs. 14.12 bbls.	2,295 lbs. 14.17 bbls.	1,458 lbs. 9.0 bbls.

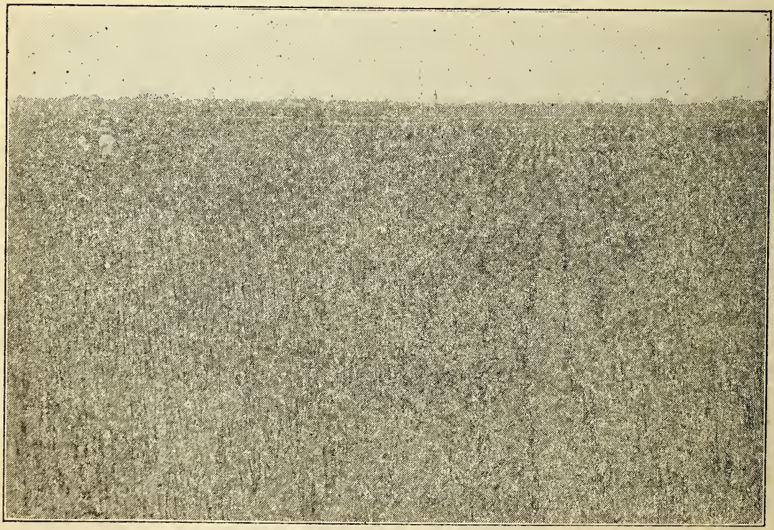


Fertilizer Plots during harvest from Water Tower.

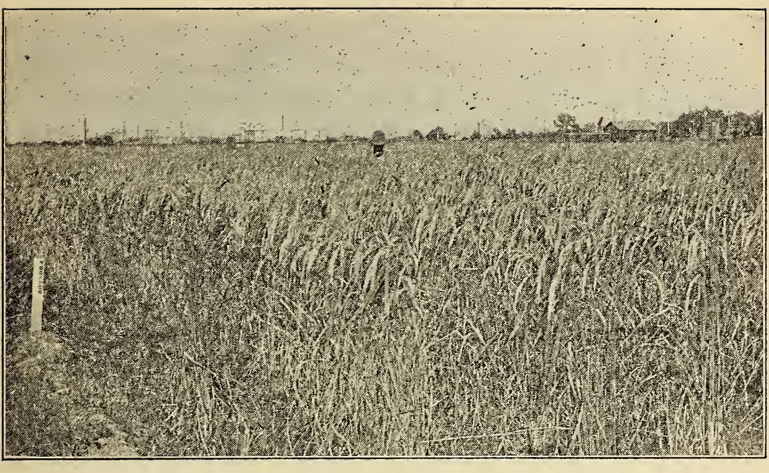


Fertilizer Plots, Station Buildings.

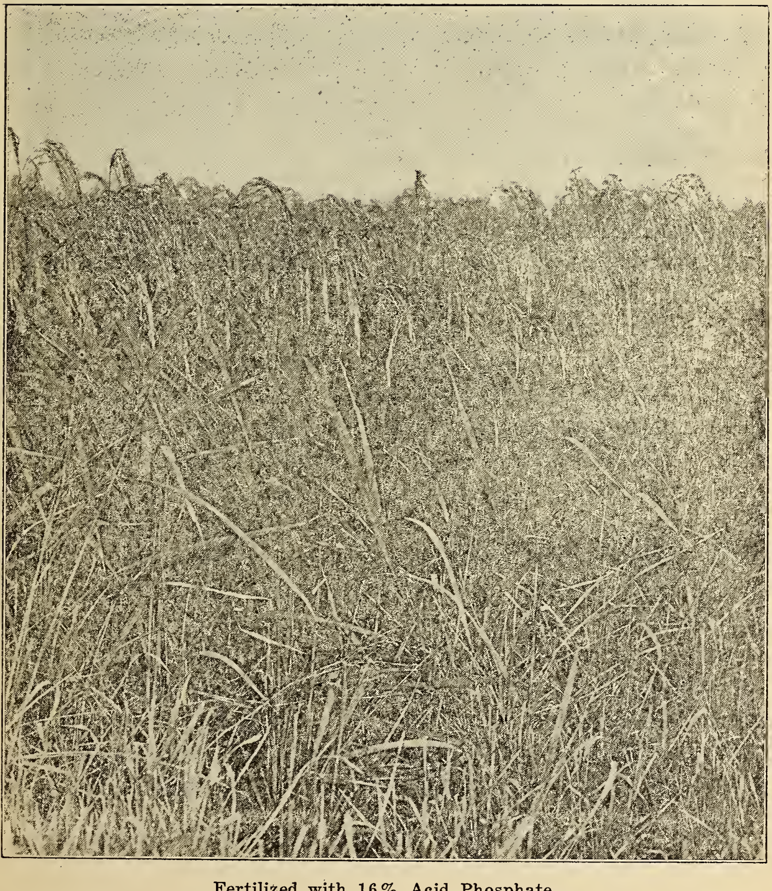
After six years of continuous application of Acid Phosphate fertilizer. Note the grass between the rows.



Check Plot—No fertilizer for six years—No grass between the rows.



Honduras Rice fertilized with complete fertilizer.



Fertilized with 16% Acid Phosphate.

Table 1 gives data for seven years on plots 1 to 8 inclusive. Plots 1, 2, and 3 is an experiment with different applications of acid phosphate. Plot 4 is a check having no fertilizer. Plots 5, 6, and 7 is an experiment with different amounts of potash in the form of German Kainit. In plot 8 is a mixture of potash and phosphate.

The plots were all planted to Honduras rice the first year 1910. As Honduras has about the same period of growth as red rice it was found difficult to hand pick the red rice from the plots with this variety. Shinriki (Japan) was used the second year (1911) for the reason that red rice heads several weeks before Shinriki, making it therefore easy to observe and hand-pick the red rice and prevent a seeding on the land. It was found difficult to obtain good Shinriki seed. As Blue Rose had all of the advantages with reference to long growing season, and as it was possible to secure a uniform seed, the experiment was concluded with this variety.

Experiment with Acid Phosphate:

Plots 1, 2, and 3 were fertilized with 16 per cent. acid phosphate to the amount of 200, 400, and 600 pounds per acre, respectively. The effect of the phosphorus could be observed on these plots while the rice was growing. It will be seen from the table that the 200-pound application produced the most profitable results during the entire experiment. The 400 pound-application did not produce enough more rice to pay for the difference in the cost of the fertilizer. The 600-pound application did not make as good a yield as the 200-pound application. Through the entire experiment of seven years no weeds or grass grew on the check plot (No. 4). Water crab grass commenced growing on the phosphate plots during the fifth year. During the last two years that the plots were planted, 1915 and 1916, all of those having applications of acid phosphate were over 50 per cent. grass. Every effort was made to check the grass by harrowing the rice after it came up and by different methods of flooding. The grass was water crab grass and barnyard millet, both common to the rice fields of

TABLE No. 2.

PLOT	9	10	11	12	13	14	15
COST PER ACRE	$4.45	$4.40	$4.05	$6.00		$7.80	$3.75
FERTILIZER POUNDS	Phos. 400 ℔ Kainit 200℔	Phos. 200 ℔ C.S.M. 200℔	Kainit 200℔ C.S.M. 200℔	Kainit 400℔ C.S.M. 200℔	CHECK	Manure 15 loads P. 400 K. 150	Manure 15 loads
1910 HONDURAS Lbs. and Bbls.	Red Rice 1,344 lbs. 8.3 bbls.	Red Rice 1,004 lbs. 6.2 bbls.	1,717 lbs. 10.6 bbls.	1,846 lbs. 11.4 bbls.	1,263 lbs. 7.8 bbls.	2,494 lbs. 15.4 bbls.	2,240 lbs. 13.82 bbls.
1911 JAPAN	1,749 lbs. 10.80 bbls.	1,688 lbs. 10.3 bbls.	1,782 lbs. 11.0 bbls.	1,506 lbs. 9.3 bbls.	1,441 lbs. 8.9 bbls.	Red Rice 1,215 lbs. 7.5 bbls.	Red Rice 1,835 lbs. 11.33 bbls.
1912 BLUE ROSE	3,904 lbs. 24.1 bbls.	3,871 lbs. 23.9 bbls.	3,272 lbs. 20.2 bbls.	3,823 lbs. 23.6 bbls.	3,385 lbs. 13.6 bbls.	3,752 lbs. 23.2 bbls.	3,471 lbs. 21.55 bbls.
1913 BLUE ROSE	2,374 lbs. 14.66 bbls.	2,792 lbs. 17.24 bbls.	3,288 lbs. 20.3 bbls.	2,956 lbs. 18.25 bbls.	2,387 lbs. 14.74 bbls.	2,237 lbs. 13.81 bbls.	2,475 lbs. 15.28 bbls.
1914 BLUE ROSE	Grass 1,483 lbs. 9.16 bbls.	2,114 lbs. 13.05 bbls.	2,690 lbs. 16.67 bbls.	2,593 lbs. 16.01 bbls.	2,527 lbs. 15.6 bbls.	2,099 lbs. 12.96 bbls.	2,067 lbs. 12.76 bbls.
5 YEAR AVERAGE	2,170 lbs. 13.4 bbls.	2,290 lbs. 14.14 bbls.	2,551 lbs. 15.75 bbls.	2,545 lbs. 15.71 bbls.	2,519 lbs. 15.55 bbls.	2,360 lbs. 14.57 bbls.	2,421 lbs. 14.95 bbls.
1915 BLUE ROSE	Grass 612 lbs. 3.78 bbls.	Grass 1,163 lbs. 7.19 bbls.	No Grass 2,462 lbs. 15.20 bbls.	No Grass 2,203 lbs. 13.6 bbls.	No Grass 2,384 lbs. 16.60 bbls.	Grass 842 lbs. 5.20 bbls.	Grass 1,377 lbs. 8.5 bbls.
1916 BLUE ROSE	Grass 777 lbs. 4.8 bbls.	Grass 1,409 lbs. 8.7 bbls.	1,798 lbs. 11.1 bbls.	1,749 lbs. 11.1 bbls.	1,992 lbs.	Grass 2,057 lbs. 12.7 bbls.	Grass 2,381 lbs. 14.7 bbls.
7 YEAR AVERAGE	1,749 lbs. 10.8 bbls.	2,003 lbs. 12.37 bbls.	2,430 lbs. 15.0 bbls.	2,430 lbs. 15.0 bbls.		2,099 lbs. 12.7 bbls.	2,199 lbs. 13.56 bbls.

Southwest Louisiana. The first five crops are averaged for the reason that they are considered profitable crops. The last two crops cannot be said to be profitable. It would seem, therefore, that grass may be a limiting factor in the use of phosphate fertilizer on land where rice is grown continuously without change or rotation for a period of more than five years.

Potash Experiment:

It will be observed in Table 1 that during the first year the results through the use of Kainit are very good and that during the succeeding years the yields are but little better than the checks. No weeds or grass grew on the potash plots during the entire experiment. The increased yield during the first year can only be accounted for in the possibility that the salt contained in the Kainit reacted on certain insoluble materials in the soil rendering them available to

TABLE No. 3.

PLOT	16	17	18	19
COST PER ACRE	$5.65	$9.90	$12.75	
FERTILIZER POUNDS	Phos. 200 ℔ Kainit 200 ℔ C.S.M. 200 ℔	Phos. 400 ℔ Kainit 400 ℔ C.S.M. 200 ℔	Phos. 600 ℔ Kainit 600 ℔ C.S.M. 300 ℔	CHECK
1910 HONDURAS	3,071 lbs. 18.96 bbls.	2,998 lbs. 18.51 bbls.	3,202 lbs. 19.77 bbls.	1,803 lbs. 11.13 bbls.
1911 SHINRIKI	50% Red. Abandoned.	RED RICE	RED RICE	RED RICE
1912 BLUE ROSE	3,385 lbs. 20.9 bbls.	3,385 lbs. 20.9 bbls.	3,418 lbs. 21.1 bbls.	2,397 lbs. 14.8 bbls.
1913 BLUE ROSE	50% Red. Abandoned.	RED RICE	RED RICE	RED RICE
1914 BLUE ROSE	1,897 lbs. 11.71 lbs.	1,895 lbs. 11.7	1,770 lbs. 10.93 bbls.	1,928 lbs. 12.52 bbls.
1915 BLUE ROSE	50% Grass 1,183 lbs. 7.8 bbls.	GRASS 792 lbs. 4.8 bbls.	GRASS 251 lbs. 1.5 bbls.	No Grass 1,335 lbs. 8.3 bbls.
1916 BLUE ROSE	Grass cut for hay in July.	Cut for Hay.	Cut for Hay.	Cut for Hay.

plants. Again, it has been observed that after land has been irrigated with brackish water that the yield of the following rice crop is much increased. The soil of these plots may be said to be in a puddled condition. Rice has been grown on them for a number of years before the land was used for this experiment and the vegetable content of the soil was very low. According to the soil analysis the soil of these plots contained an abundance of potash.

Results from Combinations:

No increase in yield was noted in plots where combinations of fertilizers were used. The results on Plot 8 are of little value for the reason that there seemed to be an area of red rice on this plot which was very difficult to eradicate. Red rice came up each year in such quantities that removing it damaged the crop materially.

Nitrogen in the form of cottonseed meal seemed to give good results with Honduras rice, but the yields were not increased in the same proportion with Blue Rose and Shinriki. (See Table 2.) In plots having phosphate in the mixture the same results with reference to grass are noted as in Table 1. There is no grass in Plot 13 which is a check plot. Neither is there grass in Plots 11 and 12 which are treated with Kainit and cottonseed meal.

The results on the plots treated with manure (Table 2, Plots 14 and 15) are not considered reliable for the reason that there was so much red rice germinated each year that in pulling it the yields were materially reduced. During the last three years of this experiment the yield was reduced at least 50 per cent. by grass in the rice. Straight head disease, which usually occurs on land that has been manured or that which contains a large amount of vegetable matter, did not occur in any of these plots.

Plots 16 to 19, Table 3, are interesting for two reasons: first, they indicate, as mentioned in a previous paragraph, that Honduras rice responds very readily to Nitrogen fertilizer; and second, the difficulty in eradicating red rice.

In 1909 a heavy crop of red rice was shattered on the land by a severe September storm. Following this the land was plowed about five inches deep. The rice raised on these plots in 1910 graded No. 1. As will be noted in the table, when this stratum of red rice was plowed up the following year (1911) so much germinated that the rice could not be hand-cleaned without destroying the stand. The following year (1912) seed rice was produced. In 1913 the red seed was turned up again and the crop was cut for hay. In 1914 seed rice was again raised. The last two years of the experiment (1915-1916) the crops were of no value on these plots because of the excessive growth of grass. On Plots 17 and 18 the effect of the excessive use of fertilizer could be observed in 1915 and was very marked in 1916. The rice came up to a good stand. When six inches high it commenced to turn yellow and growth ceased. Grass grew so rapidly that the rice was soon destroyed. In 1916 the effect of the fertilizer was evident in the growth of the grass. One of the objects of this experiment was to secure data on maximum quantity of fertilizer that may be used and the length of time that it may be continued.

Experiments with Raw Rock Phosphate:

Eight plots were devoted to this purpose in 1912, and the experiment was continued three years and finally abandoned because of red rice. In this experiment rice was in a two-year rotation with corn and peas with a winter cover crop of oats. A comparison was made between raw rock phosphate, basic slag, and 16 per cent acid phosphate. The same amount of the element phosphorus was used on each plot. The raw rock was applied once in four years and the other fertilizers applied each year. During the four years all of the plots received the same amount of phosphorus. Fifty pounds per acre of muriate of potash was used on each plot each year. Raw rock was used with and without stable manure.

The results from this experiment are of little value because it was impossible to eradicate the red rice in a rotation with corn.

From the results obtained it would seem that raw rock phosphate is of little, if any, value on rice land. Basic slag is not as good a phosphate fertilizer as 16 per cent. acid phosphate.

Experiments with Lime in Rice:

Two experiments were conducted with lime. In one a plot was planted to rice, with one-half of the plot treated with ground limestone at the rate of 2,000 pounds per acre. On another plot one-half of the area was treated with hydrated lime in the same amount. There was no difference in the yield of rice between the limed and unlimed sections. It was observable that the water plants other than rice did not seem to thrive as well on the lime as on the unlimed sections; in fact, the line of demarkation could be seen in the field. There was also a possible improvement in the physical condition of the soil on the limed sections.

Cyanamid Experiments:

Some experiments were conducted, in cooperation with a farmer near Crowley, with cyanamid. The experiment was not conclusive because of red rice. From the results that were observed in this experiment and in another experiment on reclaimed land near Florence, La., there is little to recommend cyanamid as a rice fertilizer.

Fertilizer Experiments on Reclaimed Land:

Because of difficulty in producing crops including rice on certain reclaimed marsh areas of Southwest Louisiana, it was thought advisable to conduct some fertilizer experiments on this type of soil. A cooperative experiment was conducted in 1916 with the White Lake Land Co. on the farm of A. P. Alley, two miles west of Florence, Vermilion Parish, La., in Unit 1 of the White Lake Reclamation Project.

The land of this experiment had been drained for three years. The original humus was from six to ten inches deep. At the time of this experiment it had been mixed with about six inches of the grey soil on which it rested. The soil was in good physical condition. From the appearance and the chemical analysis one would be led to believe that it would produce in abundance any crop adapted to this section of the country. As a matter of fact unless fertilizer is used no crop would grow. The seed would germinate well and the plant make good progress until about five inches high at which time it would stop growing, turn yellow, and in a short time die. All crops including rice behaved in this way. It was definitely established that the trouble was not due to either disease or insects. At the time when it was first drained the soil was strongly acid but at the time of the experiment, three years later, there was no acid reaction to blue litmus except in the bottom of the deeper drains where there was undisturbed humus.

The results of these experiments are believed to be of enough importance to publish all of the notes in connection with each of the plots. Twenty plots, each having an area of 0.77 acres were used in this experiment. The plots were in two ranges of ten plots each, which will be indicated respectively as Range "A" and "B".

Range "A" South of Road on Alley Farm,

Rice Experiments, Ten Plots.

All of the rice on this range planted May 15, 1916. Seeded with a rice drill at the rate of 65 pounds per acre.

Plot 1. Fertilizer 100 pounds per acre 16 per cent. acid phosphate. Blue Rose variety. Good stand. Yield per acre, 2,656 lbs. (16.4 bbls.).

Plot 2. Fertilizer 200 pounds per acre 16 per cent. acid phosphate. Variety Blue Rose. Good stand. Yield per acre, 2,673 lbs. (15.5 bbls.).

Plot 3. Fertilizer 300 lbs. per acre 16 per cent. acid phosphate. Blue Rose variety. Good stand. Yield per acre, 1,863 lbs. (11.5 bbls.).

Plot 4. No fertilizer. Check plot. Good stand. Blue Rose variety. Yield per acre, 810 lbs. (5 bbls.).

Plot 5. Fertilizer bone meal 150 pounds per acre. Variety Blue Rose. Good stand. Yield per acre, 1,620 lbs. (10.0 bbls.).

Plot 6. Fertilizer 75 pounds per acre phosphate-cyanamid. Variety Blue Rose. Good stand. Yield per acre 923 lbs. (5.7 bbls.).

Plot 7. Fertilizer 200 lbs. 16 per cent. acid phosphate, 100 lbs. cottonseed meal per acre. Variety Blue Rose. Good stand. Yield per acre 1,684 lbs. (10.4 bbls.).

Plot 8. No fertilizer. Check plot. Blue Rose variety. Yield per acre 453 lbs. (2.8 bbls.).

Plot 9. Fertilizer 200 lbs. 16 per cent. acid phosphate. Variety Experiment Station selection No. 1162. Stand poor. This rice is a special selection which is earlier than Honduras. It is very uniform in size and shape of grain. This variety should have been planted in March to get the best results. Yield per acre 3,419 lbs. (21.11 bbls.).

Plot 10. Data on this plot of no value due to error in planting.

NOTE: A strip thirty-five feet wide was limed across the south side of all of these plots. Each plot in this section limed at the rate of 2,000 pounds per acre with ground limestone.

There was no increase in yield or any other effect observable on the limed sections.

Range "B". Plots North of the Road on the Alley Farm, Corn and Miscellaneous Crops.

All crops in this range planted March 11, 1916. Area each plot one-half acre.

Plot 1. Fertilizer none. Check plot. Planted to Fergusons Yellow Dent Corn. Yield per acre 4.20 bushels.

Plot 2. Fertilized with 1,500 pounds per acre ground limestone. Yield per acre 2.24 bushels.

Plot 3. Fertilizer 200 pounds per acre 16 per cent. acid phosphate, and 100 lbs. per acre German Kainit. Yield per acre 6.1 bushels.

Plot 4. Fertilizer 16 per cent. acid phosphate 200 lbs. per acre and lime 1,500 pounds per acre. Yield per acre 14 bushels.

Plot 5. Fertilizer 15 loads stable manure and 200 pounds 16 per cent. acid phosphate per acre. Yield 27.6 bushels per acre.

Plot 6. No fertilizer. Check plot. Yield per acre 2.4 bushels corn.

Plot 7. Fertilizer bone meal 200 pounds per acre. Yield per acre 6.18 bushels corn.

Plot 8. Fertilizer 200 pounds per acre 16 per cent. acid phosphate and 150 pounds cottonseed meal. Yield 13.4 bushels corn.

Plot 9. Fertilizer 200 pounds per acre 16 per cent. acid phosphate and 100 pounds cottonseed meal. Yield per acre 14.08 bushels corn.

Plot 10. Fertilizer 200 pounds per acre 16 per cent. acid phosphate. Yield per acre 19.4 bushels corn.

The above experiments would seem to indicate that 16 per cent. acid phosphate is the best form of commercial fertilizer that can be applied to reclaimed lands for either corn or rice. In the case of highland crops, farm manure balanced with phosphorus will probably produce the best results. It would seem that while this land contains an abundance of vegetable matter, it is of a peaty nature; therefore, the addition of animal and green manure adds the necessary bacterial life which this soil requires. It is suggested that cover crops be planted whenever possible on all of this type of land. Oats, if fertilized, is a good winter cover crops. Legumes such as cowpeas, soybeans, and velvet beans, if fertilized with acid phosphate, should be grown wherever possible during the summer.

How to Mix Fertilizers on the Farm.

The experiments outlined in this bulletin are from the standpoint of home mixing of fertilizers with farm labor. It has been the policy of fertilizer manufacturers to make the formulas and information with reference to commercial fertilizer as difficult as possible for the farmer to understand. If reduced to plain terms it should not be difficult for any farmer having knowledge of arithmetic to not only understand the meaning of formulas but be able to calculate the amount of the ingredients of any formula that he may desire to make up.

In 1914 a circular was published by the Rice Station giving these directions. The war has of course made a change in the price of the fertilizer, but the principle involved is the same. Therefore, the information contained in this circular is given herewith using the prices of 1914 and Crowley as the point of delivery of the materials.

Phosphorus:

Found largely in the seed. Available phosphorus in soils makes plants vigorous and fruitful. Functions in the formation and movement of proteids.

South Louisiana soil is deficient in phosphorus. It will probably always be necessary to use this element of plant food in the form of commercial fertilizer.

The cheapest form of available phosphorus is in the form of 16 per cent acid phosphate. This will cost in bulk car lots, Crowley, about $12 per ton.

Potash:

Facilitates starch formation and makes the stems strong and hard. In some instances potash seems to harden the fruit. According to chemical analysis there is an abundance of potash in our soils. If, however, crops are not rotated and vegetable matter burned under, it is possible that it may become insoluble and therefore not available for the use of the plants. If land is planted continuously to rice, it is possible that some potash fertilizer will be required. If land is changed, or if a rotation of crops is practiced, the addition of potash is not believed to be necessary.

Potash can be purchased in the form of German Kainit, Muriate of Potash, and Suphate of Potash. In ordinary times these materials will cost Crowley: Kainit, 12 per cent. potash, $12.25 per ton; Muriate of Potash, 48 per cent. potash, $39.50 per ton.

Cottonseed meal which is properly classed as a source of nitrogen contains in addition to the approximate 6½ per cent. nitrogen about 2 per cent. potash.

Nitrogen:

This is the most costly of all elements of plant food when purchased in the form of commercial fertilizer. Available nitrogen accelerates the growth of the leaf and stalk. It can be bought on the market in the form of cottonseed meal, blood meal, tankage, and sulphate of ammonia. All of these are good rice fertilizers. It is not advisable to use nitrate of soda on rice. Cottonseed meal contains about 6½ per cent. nitrogen, sulphate of ammonia 20 per cent., tankage 6 to 9 per cent., and blood meal 14 per cent.

The cheapest source of nitrogen is through the growing of legumes such as the cowpea, clovers, or the velvet bean. the farmer should prepare to ultimately secure all of his nitrogen through the legumes and purchase no nitrogen in the form of commercial fertilizers.

A good crop of cowpeas or soybeans, if turned under, not only contributes nitrogen contained in the vines but adds an abundance of vegetable matter which is very necessary to all rice soils. A crop of cowpeas will yield approximately 78 pounds of nitrogen, which, if purchased in the form of chemicals would cost about $14 per acre.

Farm Manure:

If cottonseed meal be fed to livestock and the manure properly cared for, the full feeding value of the protein is obtained, and a large percentage of the nitrogen is returned to the soil. If stock is lot fed and the manure hauled to the fields, there is a possible loss of from 25 to 50 per cent. If the stock are pastured on the fields which are to be cultivated, the loss is only from five to ten per cent. Thus, a ton of cottonseed meal, costing $28, could be fed to cattle and the farm would receive $25.20 worth of fertilizer in the form of nitrogen.

Animal manure when balanced with phosphorus is considered to be the best fertilizer in the world.

Summary:

1. Sixteen per cent acid phosphate at the rate of 200 pounds per acre seems to give the best results in the late varieties of rice such as the Japans and some of the Wright varieties.
2. From these results it would seem that it is not profitable to grow rice longer than five or six years in succession through the use of phosphate fertilizer.
3. Phosphoric acid seems to be the best fertilizer for all crops on reclaimed marsh land.
4. Nitrogen can be used to advantage on the early varieties such as Honduras. Small applications of nitrogen may be of advantage on land that is in a badly run-down condition when planted to other varieties.
5. Potash does not seem to be required in the form of commercial fertilizer.
6. Most rice land needs vegetable matter.
7. Home mixed fertilizers are the most profitable.

How to Estimate Any Fertilizer Value.

If acid phosphate contains 16 per cent. phosphoric acid, and there are twenty hundred in a ton, 20 multiplied by 16 (the number of pounds of available material contained in each hundred pounds) equals 320 pounds which is the normal amount of available phosphoric acid contained in a ton of acid phosphate. Divide $12 by 320; the result is 0.0375 which is the cost per pound of the phosphoric acid f. o. b. Crowley.

The same method is used in calculating the cost per pound of potash and nitrogen.

The cost of the available materials f. o. b. Crowley is as follows.

Available phosphate, 0.0375 cents per pound.
Available potash, 0.05 cents per pound.
Available nitrogen, 0.18 cents per pound.

Example. Make a 10-0-2 fertilizer. The first numeral refers to phosphoric acid, the second to nitrogen, and the third to potash. In the Rice Belt very little nitrogen is used because of the excessive growth of straw; therefore, the average farmer looks upon a "10-2" fertilizer as one containing ten per cent. of phosphoric acid and two per cent. potash. In other sections of the country the second numeral always means nitrogen.

Suppose that 10-0-2* fertilizer costs $14.75 f. o. b. New Orleans. Freight to Crowley in car lots is $2.50 per ton—less than car lots $5.00 per ton. Therefore, 10-0-2 fertilizer will cost in car lots delivered in Crowley $17.25 per ton.

What should the above fertilizer be worth, or how much would it cost to mix same on the farm with farm labor? If there are 10 pounds per hundred of phosphoric acid and twenty hundred in a ton, 200 pounds of the available material would be required; this multiplied by $0.0375 (see previous paragraph) equals $7.50. There are 2 pounds per hundred of potash and 20 hundred in a ton; therefore, 40 pounds of available potash are required which at 5 cents per pound, equal $2.00 plus $7.50 for the phosphoric acid, makes a total of $9.50 which is the value of the available materials in a ton of 10-0-2 fertilizer. To this add $1.00 which is a liberal price for farm mixing. The fertilizer can, therefore, be mixed on the farm for about $10.50 per ton.

What is required for 10-0-2 fertilizer. Take 1,250 pounds of 16 per cent. acid phosphate (see table) and 84 pounds of muriate of potash, making a total of 1,334 pounds and 666 pounds of any dry inert material that will do for filler; shovel three times through a sand screen, and there will have been manufactured one ton of 10-0-2 fertilizer.

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*10% average Phosphoric acid, no nitrogen, 2% Potash (K_2O).

The "filler" has no fertilizing value and the charge for it should be very small, but even so there is no way of avoiding the payment of freight on a considerable amount of worthless material. The only possible value that "filler" may have is to make the fertilizer dry enough to run through the fertilizer distributor easily. Acid phosphate will usually spread without trouble. If it is necessary to use some material to take up the excess moisture, Basic Slag is good for this purpose. The Basic Slag can be purchased from $14 to $16 per ton. In this way it is possible to make use of a filler which has a high fertilizing value. Lime which has been well slacked in air may be used for this purpose if the lime has been properly slacked and if the fertilizer is to be used at once. Lime in any form should not be used with acid phosphate except with the advice of a chemist. Lime not properly air slacked will cause the phosphoric acid to "revert" to an insoluble form which is not so readily available to the plant.

From the above it may be seen that in purchasing a ton of 10-0-2 fertilizer at $17.25 per ton, that it costs $6.75 more than it will cost to make up the formula on the farm. Again granting that it is possible to purchase on the market 10-02 fertilizer for $10.50 per ton the item of 82 cents per ton freight on the filler cannot be avoided. With 666 pounds of filler in each ton the freight on same on a 30-ton car would be $24.50. The difference on a 30-ton car of 10-0-2 fertilizer at $17.25 and the home mixed article are $10.50 per ton, would amount to $202. If the application per acre is 200 pounds, the cost per acre on the ready mixed would be $1.72 and the home mixed $1.04.

Commercial fertilizer may be spread broadcast on the disced land before planting or it may be placed in the row with the seed by use of the combined fertilizer and seed drill. If there is no grass seed in the land, the one method is probably as good as the other. Observations lead us to believe that phosphoric acid accelerates the growth of certain water grasses and weeds as well as rice. If this is true, it is probably better to place the fertilizer in the row with the rice.

It is good business policy to purchase fertilizer in car lots. If it is dry, it will keep indefinitely; the car freight is one-half the local freight rate. If a car cannot be used in two years, it is well to go in with a neighbor and purchase a car. Acid phosphate should be purchased in bulk. The sack will seldom last until the fertilizer is used. It is easier and cheaper to handle in bulk. Any sacked fertilizer which is carried over to the year following will contain so many fragments of sack and so much lint that it is necessary to screen all of it before it can be used. The cost of the sacks for a ton of fertilizer in ordinary times is about $2.50 per ton.

TABLE FOR HOME MIXING

Any formula at a glance.

Percentages or units desired.	Nitrogen from nitrate of soda. 15% N.	Nitrogen from blood. 14% N.	Nitrogen from cotton-seed meal. 6½%.	Nitrogen from Ammonia Sulphate. 20% N.	Phosphoric acid from 14% acid phosphate.	Phosphoric acid from 16% acid phosphate.	Potash from muriate of potash. 48% potash.	Potash from Kainit. 12% potash.
1	133	143	306	100	143	125	42	166
2	266	286	615	200	286	250	84	333
3	400	428	923	300	430	375	126	500
4	533	571	1,230	400	570	500	168	667
5	666	714	1,538	500	715	625	210	833
6	800	857	1,846	600	860	750	252	1,000
7	933	1,000		700	1,000	875	294	1,167
8	1,066	1,142		800	1,143	1,000	336	1,333
9	1,200	1,285		900	1,286	1,125	378	1,500
10	1,333	1,425		1,000	1,430	1,250	420	1,667
11	1,460	1,571		1,100	1,570	1,375	462	1,833
12	1,600	1,714		1,200	1,715	1,500	505	2,000

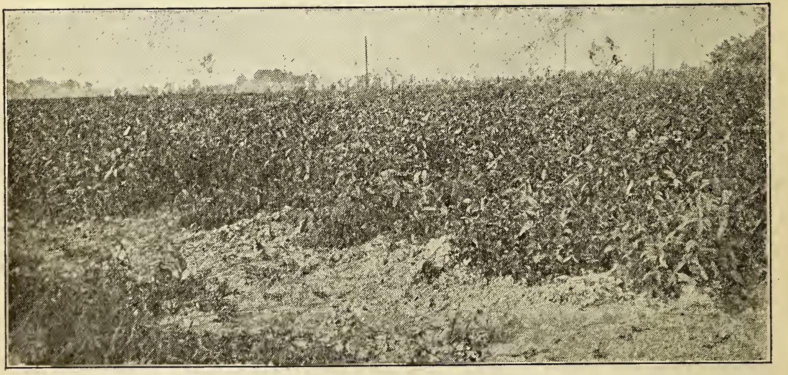
Example: To make a 10-2-2 fertilizer. First look in the 16 per cent. acid phosphate column opposite the 10 per cent. of the left hand column indicating the percentages will be found 1,250. Opposite the 2 per cent in the muriate of potash column 84 will be found. Opposite 2 per cent. in the cottonseed meal column will be found 615. Therefore, a ton of 10-2-2 fertilizer will require 1,250 pounds of 16 per cent. acid phosphate, 615 pounds of cottonseed meal, and 84 pounds of muriate of potash. This will total 1,949 pounds. It will therefore be necessary to add 49 pounds of filler to complete the ton. Any formula can be found in a similar manner.

Over 80 bu. Corn on Rice Land.

Biloxi Soy Beans on Rice Land. Does Not Shatter Badly When Ripe, and Produces a Good Yield of Beans.

Corn Growing on Rice Land in Rotation with Rice.

A Ten-ton Crop of Sorghum and Peas on Rice Land.



Barchet Soy Beans is a Good Crop to Clean Land Badly Infested with Red Rice. This Variety Makes Very Good Hay and a Fair Yield of Threshed Beans.

ROTATIONS ON RICE LAND.

It will be remembered that the Station was established on land which would no longer produce rice profitably. The soil contained a great many weed seed and an abundance of red rice seed. The problem was to establish a succesful crop rotation in which rice is a money crop. The rotation in order to be successful must eradicate the red rice with a minimum of hand cleaning. To that end four rotations were established. Two two-year rotations, a three-year rotation, and a four-year rotation. One two-year rotation is rice one year and corn and cowpeas the next with a winter cover crop of oats. The other two-year rotation is the same with the exception that the land is fallowed during the winter. The three-year rotation is corn and cowpeas, oats, peas alone, and rice. The method of planting is as follows. Corn and peas are followed by a winter cover crop of oats; the next year after the harvest of the oats, peas alone are planted. In the fall the vines are disced down and the land plowed fallowed during the winter and planted to rice the spring of the third year, completing the three-year rotation. The four-year rotation is rice two years and lespedeza two years which is comparable to the only rotation in common use, that of pasturing the land when it is not in rice.

The first year of this experiment, 1910, no fertilizer was used. The crops were not profitable. During the succeeding years the rice was fertilized at the rate of 200 pounds per acre with 16 per cent. acid phosphate, and the corn was fertilized with 200 pounds of phosphate and 100 pounds of cottonseed meal per acre.

Following is a table which gives a plan of the experiment showing the crops and the yields during the entire period that the experiment was run.

TABLE GIVING ROTATIONS AND YIELDS ON ROTATION PLOTS.

	Check; no fertilizer; rice continuously.	Two-year rotation. No cover crop of oats. Peas in corn.		Three-year rotation. Cover crop oats. Peas grown in corn.			Two-year rotation. Cover crop. Peas grown in corn.	
PLOT	20	21	22	23	24	25	26	27
1910	Rice 7.47 bbls.	Rice 7.77 bbls.	Corn 0000	Rice 8.0 bbls.	Corn 0000	Peas good crop	Rice 11.7 bbls.	Corn 0000
1911	Rice 8.66 bbls.	Corn 12.2 bu.	Rice 8.66 bbls.	Corn 21.1 bu.	Peas poor crop	Rice 17.2 bbls.	Corn 14.9 bu.	Rice 7.43 bbls.
1912	Rice 7.78 bbls.	Rice 17.4 bbls.	Corn 18.5 bu.	Peas good crop	Rice 14.2 bbls.	Corn 25 bu.	Rice 15.76 bbls.	Corn 37 bu.
1913	Rice 6.37 bbls.	Corn 30.3 bu.	Rice 13.1 bbls.	Rice blight	Corn 26.4 bu.	Peas good crop	Corn 17.1 bu.	Rice 14.4 bbls.
1914	Rice 4.62 bbls.	Rice 11.1 bbls.	Corn 14.5 bu.	Corn 21.5 bu.	Peas good crop	Rice 6.6 bbls. ?	Rice 5.4 ?	Corn 15.8 bu.
1915	Rice 2.18 bbls.	Corn 18.1 bu.	Rice 13.4 bbls.	Peas good crop	Rice 17.5 bbls.	Corn 0000 ?	Corn 6 bu. ?	Rice 16.6 bbls.
1916	Rice 10.4 bbls.	Rice 12.8 bbls.	Corn 13.7 bu.	Rice 17.5 bbls.	Corn 0000	Peas good crop	Rice 12 bbls.	Corn 14.6 bu.

NOTE—"?" means that low yield was due to bad stand or insects.

Plot 20 is a check plot on which no fertilizer is used and which up to 1915 no red rice was handpicked. Red rice is somewhat responsible for the low yield of rice up to this time. There was just as much red rice in the threshed sample in 1915 as there was in 1910. In 1916 the red rice was hand-cleaned from this plot. It was further reduced in the rice by late planting and by cultivating the land before planting to white rice. It will be noted that the yield was increased in 1916.

On the two-year rotation in plots 21 and 22 rice was planted one year and corn and cowpeas the next. This land was all in very bad shape. It had been cultivated to rice so long that little vegetable matter remained in the soil. It was not possible to plow shallow enough to keep out the yellow clay. It was found that fertilizer was necessary to produce a profitable yield of either rice or corn.

The other two-year rotation is on plots 26 and 27. The only difference is in the winter cover-crop. On both of these rotations the yields were fairly good when the season was favorable. No red rice was hand-picked until 1915, and up to this date no rice was produced on these plots which would grade better than No. 2. After the corn was laid by, red rice germinated between the corn rows and produced seed. The plan was adopted of cutting and shocking the corn as soon as the ears were mature and the leaves were "fired" about 18 inches on the ends. After the corn was shocked the middles were cultivated all that the planting of peas would permit. All red rice not growing in the peas was generally destroyed. The cutting of the corn and the cultivation was always productive of a good crop of peas. It is believed that the winter cover-crop of oats on 26 and 27 reduced the red rice to a very considerable extent. A large amount of red rice was destroyed by cultivation and the planting of the oats in the fall. The soil was filled with oat roots during the winter. When the oats were plowed under in the spring the disintegrating vegetable material caused the early germination and subsequent destruction by cultivation of a large part of the red rice which would otherwise come up in the white rice.

The same observations were made on the three-year rotation in plots 23, 24, and 25 that were made on the two-year rotations. Red rice germinated and produced seed between the corn rows and a small amount produced seed in the cowpeas when planted alone. The red rice was materially reduced but not eliminated by cultural methods in the three-year rotation. During the period that this experiment was run the red rice was reduced to a point where hand-cleaning was comparatively easy. The last two years of the experiment No. 1 rice was produced. The peas were planted in rows and cultivated. It was found that if the peas were cultivated from two to three times that a good crop could be raised in rice land. However, peas planted broadcast would not return the seed planted. The reason being that the soil being of a silty nature packs very tightly around the plant. Unless the plants are cultivated the air is excluded from the roots and they do not thrive.

In the four-year rotation (not shown in the table) rice was planted two years and lespedeza two years. This experiment was run seven years. The results were not satisfactory. The land planted to lespedeza was mowed in the summer so that the red rice could not produce seed. This corresponds to the common pasture methods. Enough red rice remained in the soil, however, so that no crop of rice in the seven graded better than No. 5.

A certain area on the Station used by the Bureau of Plant Industry, contained so much red rice that white rice could not be grown. Six clean cultivated highland crops were grown on this land. Rice was planted and a heavy yield of seed rice was secured. This indicated that a longer rotation than any of the above indicated is required for the eradication of red rice.

CONCLUSIONS TO BE DRAWN FROM THE ROTATION EXPERIMENTS.

1. Short rotations of 2, 3, and 4 years with rice do not seem to be profitable. This is not because the crops in question do not make profitable yields, but because of the high overhead expense necessitated by the frequent change

from rice to highland crops. When highland crops are raised deep ditches are necessary for drainage. When rice is raised on this land, some of the ditches must be filled and the entire area leveled in contour.

Attention is invited to the fact that through the use of phosphate fertilizer five profitable crops of rice were produced on land that was considered worn out, or below profitable production. It seems reasonable to believe that with clean land containing an abundance of vegetable matter, as would be the case after a number of years of highland rotation, that at least six and possibly seven profitable crops of rice may be produced in succession; this, of course, if care is exercised in the selection of seed, all red rice hand-pulled, and fertilizer used. It is therefore believed that the average rice farm should be divided into two parts. One part should be devoted to a rotation of highland crops for possibly six years and the other to rice for the same length of time. After which the rice and highland areas are interchanged. In this way the overhead expense of the ditches in the one case and the levees in the other would be materially reduced. As evidence to support this theory the writer could indicate a number of good conservative farmers in the Rice Belt who have attempted to rotate highland crops with rice and have failed because of the overhead expense which the short rotation has necessitated.

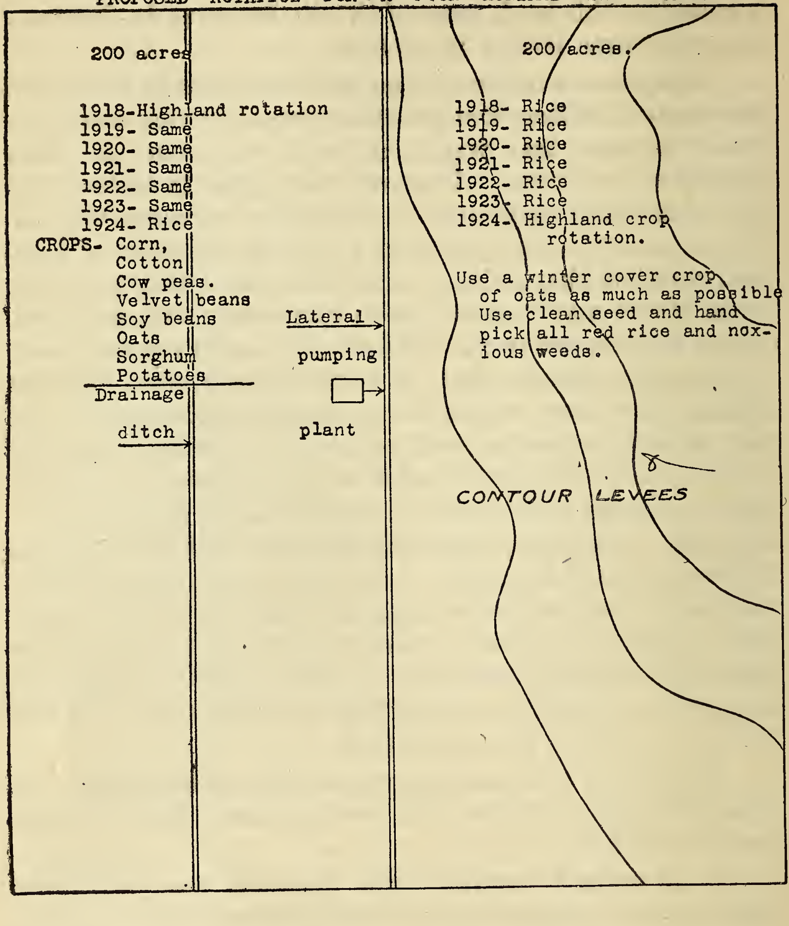
2. Corn is not a good crop to clean rice land for the reason that the red rice will produce seed after the corn has been laid by.

3. In order to eradicate red rice some clean cultivated crop such as soybeans or cotton should be used.

4. Cowpeas or velvet beans will produce a good crop on rice land if planted in rows and cultivated. Cowpeas will not produce profitable returns if planted broadcast.

5. Following is a suggested rotation for a 400 acre rice farm.

PROPOSED ROTATION FOR A FOUR HUNDRED ACRE FARM.



200 acres

1918-Highland rotation
1919- Same
1920- Same
1921- Same
1922- Same
1923- Same
1924- Rice

CROPS- Corn,
Cotton
Cow peas.
Velvet beans
Soy beans
Oats
Sorghum
Potatoes

200 acres.

1918- Rice
1919- Rice
1920- Rice
1921- Rice
1922- Rice
1923- Rice
1924- Highland crop rotation.

Use a winter cover crop of oats as much as possible. Use clean seed and hand pick all red rice and noxious weeds.

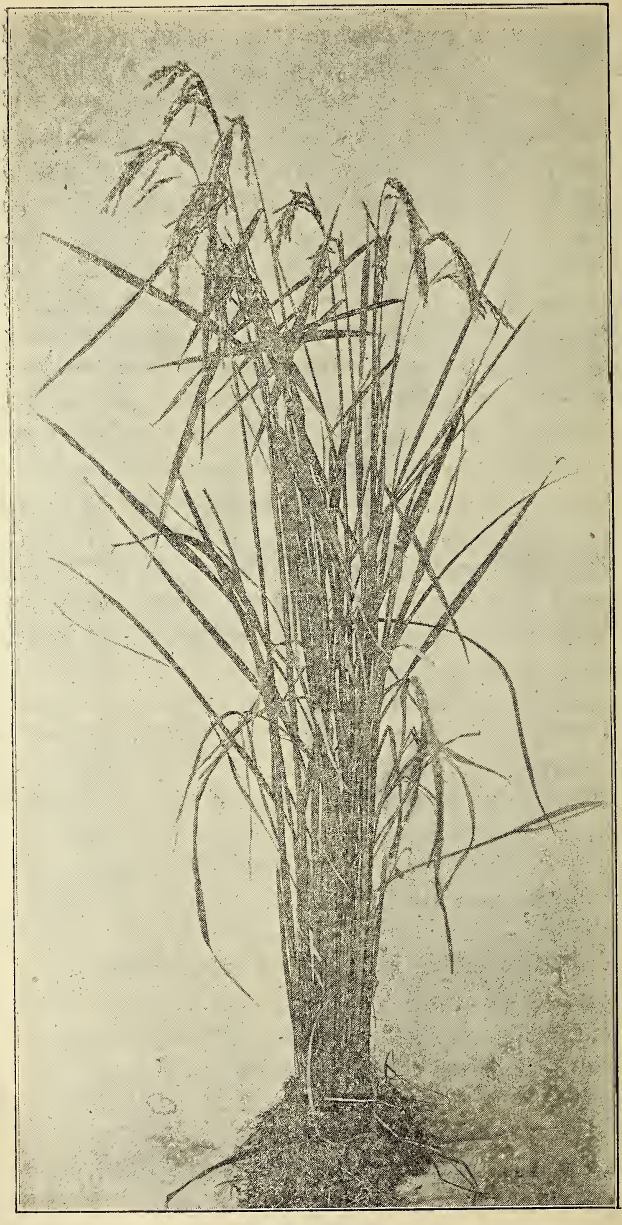
RED RICE.

Red rice is probably a true variety of rice for the reason that it is possible to cross it on a white rice and produce a hybrid. In earlier investigations with rice, botanists describe it as a rice species and give it the name of *Oryza Rufipogon.* Ordinary white rice is *Oryza Sativa.*

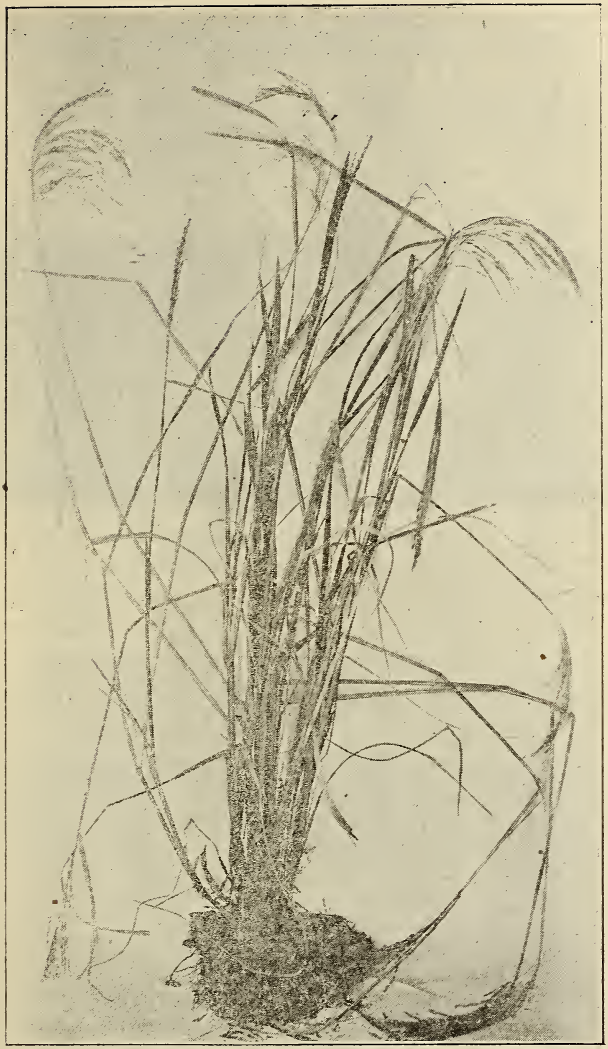
Red rice in the rough is a little smaller than the other varieties which are commonly grown. Under the rough outer husk the cuticle covering the grain is a dark red. Under the red cuticle the grain is a pinkish white. The milled sample, therefore, even though it be very highly finished, is dark in color. It is impossible to produce a first grade sample of milled rice if it contains a very high percentage of red rice. The six grades of rough rice are made largely on the percentage of red contained in the sample.

Red rice would not be so objectionable if it were possible to produce a good yield in the field. It has, unfortunately, developed all of the characters of a weed. In manner of growth it is spreading. White rice grows erect on a strong straw which will withstand a considerable amount of wind and rain when ripe. Red rice on the other hand has a very weak straw which breaks and bends almost before the rice is ripe. Again, red rice has developed the weed character of shedding the seed as soon as they are ripe. If red rice is cut just before it is ripe, the shattering in cutting and shocking is not excessive. After it has become dry in the shock, more than 50 per cent. will be lost in moving it from the field to the threshing machine. It is not believed to be possible to save more than 40 per cent. of the red rice which is produced in the field.

The red rice which is shattered is more or less mixed with the soil by the teams and implements of harvest. When well coated with silty mud the seed will retain its vitality indefinitely. Just how long this may be is not known, but there are a number of instances on record where the seed has germinated after being in the ground for 12 years. On the Station where seed rice is now being produced it is possible to secure a good stand of red rice by plowing one-



WHITE RICE.
Note the difference in the manner of growth.



RED RICE.
Note the difference in the manner of growth.

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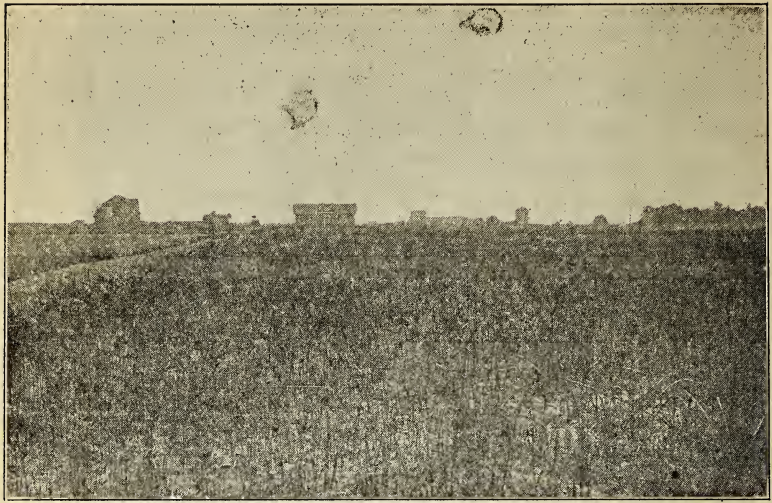


VOLUNTEER RED RICE.

Hand-picking Red Rice. If clean seed is used and care exercised, Red Rice cannot get a foothold in the field.

half inch deeper than the land has been cultivated during the past seven years. The red rice problem is probably the most serious of any confronting the rice farmer of the Gulf Coastal Plain. Red rice is merely the result of careless methods on the part of the farmer of that region. In order to have red rice the seed must be planted. White rice does not turn into red rice as certain farmers are inclined to believe. It is possible that some red rice may be scattered by livestock. Manure from rice straw bedding which contains red seed may be the means of spreading a small amount on the field. The principal means of propagation, however, is that of planting the red seed with the white. It is somewhat difficult to secure rice seed which is absolutely free from red rice. Care should be exercised to reduce the amount purchased in the seed to a minimum. It is then comparatively easy and inexpensive to hand-pull the red rice from the field. As soon as the red rice heads it is easy to distinguish it from the white rice. To the farmer who desired to follow lax methods the red rice problem would seem an insurmountable one. To the careful farmer who adopts the proper rotation of crops in connection with livestock, red rice cannot be considered a difficult problem. If the land is clean—does not contain red rice seed—careful selection of seed and hand-cleaning in the fall will insure clean land and a good grade of rice. There are farms in the Rice Belt which have been in cultivation to rice for over 25 years and have never raised a grade under No. 1.

Methods Which Will Aid in Eradicating Red Rice in Badly Infested Fields.

1. *Winter cover-crops.* Mow the stubble as soon as the rice is threshed. This will aid in germinating the red seed which may be on the surface of the ground. If the stubble is not too heavy on the ground, double-disc the land twice. This will, under ordinary circumstances, produce a fair seed bed. The tractor disc heavily weighted is especially good for this purpose. Plant to native Louisiana Rust Proof Oats with a disc drill or sow them broadcast and finish covering

with a corrugated land packer after harrowing them in. If the stubble is too heavy on the ground to disc, the land should be plowed as shallow as possible and prepared and planted to oats. The disc is even better than the shallowest plowing for the reason that all of the red rice is "planted" on the surface. The fall rains will germinate a large amount of it, and a high percentage of the balance will germinate in the spring. If the stubble is not mowed but plowed in the ordinary way in the fall, the red rice seed will be turned under several inches and sealed up in the soil until that stratum is again plowed up in subsequent cultivations. For a striking illustration of this see the notes on Plots 16 to 19 in fertilizer experiment on page......... In this experiment seed rice was produced every other year and a crop of red rice destroyed every other year. If it is not possible to plant the oats, the stubble should at least be mowed and disced.

2. *Winter cover-crops.* It is believed that a winter cover-crop is a great aid in the eradication of red rice. As before explained, red rice will become embedded in the soil and will not germinate until the soil covering is broken admitting air and permitting the seed to sprout. The soil is filled with roots of the winter crop. When these roots disintegrate in the spring it aids in the germination of the red rice. Again, with reference to the winter cover-crop, it should be remembered that in the latitude of the Rice Belt bacterial action occurs in the soil, because of the absence of frost during a large part of the winter. Plant food which may become available through this action, if not taken up by the roots of the oat or other winter cover-crop, may possibly assume insoluble form unavailable for the succeeding rice crop. If this plant food is taken up by the oats and returned to the land in the spring, the food thus gathered is made available for the succeeding crop of rice. This should be especially valuable in the case of nitrogen which the rice plant makes use of only in the form of ammoniates. Under irrigated conditions decaying vegetable matter of course produces ammoniates through the action of the anaerobic bacteria. This being the case it would seem that the decaying oat plants would tend to feed the rice plant during

a large part of the growing season. It is believed, therefore, that the rice farmer should plant oats as a cover crop on rice land whenever possible.

3. *Cultivated crops.* On land badly infested with red rice preference should be given to clean cultivated crops until the red rice is under control. Soybeans and cotton are very desirable for this purpose. Sorghum and peas or velvet beans grown for silage are very useful because the crop is harvested and the land cultivated before it is possible for any volunteer red rice to produce seed. Corn, peas, and sweet potatoes may be used on rice land. It is necessary to cut and shock corn or cut it for silage in order to destroy the red rice between the rows by cultivation before the red rice has time to produce seed. In the case of all three of these crops it may be necessary to hand-hoe the red rice from between the rows.

4. *Livestock.* Livestock is a great aid in the eradication of red rice for the reason that red rice is a very good feed, and stock will eat all that germinates on pasture land. If land is pastured closely, little if any red rice will germinate after the second year. It should be remembered, however that the seed which is sealed up in the soil is not disturbed and will germinate the first time that the land is cultivated.

RICE INSECTS.

Root Maggot,
(*Lissorphoptrus Simplex*).

With reference to this insect it is believed to be worth while to publish the work done by J. L. Webb of the U. S. Bureau of Entomology. Mr. Webb, Mr. Hood, and Mr. Tucker, of the U. S. Bureau of Entomology, worked three years on rice insects. Following is the report of Mr. Webb:

NOTES ON THE RICE WATER-WEEVIL (LISSORHOPTRUS SIMPLEX SAY)

By J. L. WEBB, *Bureau of Entomology*

(Reprinted from Journal of Economic Entomology, Vol. 7, No. 6, 1914)

The amount of damage done yearly to the rice crop by the rice water-weevil is extremely hard to estimate. In most cases no rice is killed outright. On the other hand practically every rice field is infested to a greater or less degree. The effect of an attack is the pruning off of the roots near the base of the stalk. In severe attacks all the roots may be cut off, in others only a few. Where the pruning is not too severe, the rice plant promptly throws out new roots, continues to live, and will mature. Yet we do not know just how much has been lost in weight or quality of yield. The difficulty is in finding a field of rice entirely free from attack with which to compare infested fields. In extreme cases the rice plants are killed and the loss is then more easily estimated. In general, however, the loss from this source is considerable and well worth active efforts in the way of prevention or elimination.

SEASONAL HISTORY AND HABITS

According to the writer's observations the adult passes the winter in dead grass, especially grass that is matted upon the ground. In order to find the weevils in hibernation the grass must be lifted up and thoroughly shaken out, allowing them to fall to the ground. Close examination of the debris is then necessary in order to distinguish the weevils, as their general color is much the same as that of the dry grass. Great numbers of weevils pass the winter in this way. Mr. C. E. Hood, one of the writer's predecessors in the study of the biology of this insect, records the finding of large numbers of hibernating weevils in Spanish moss. The writer believes Mr. Hood's observations to be correct, but from his own experience he has come to the conclusion that dead grass is the more favored place of hibernation.

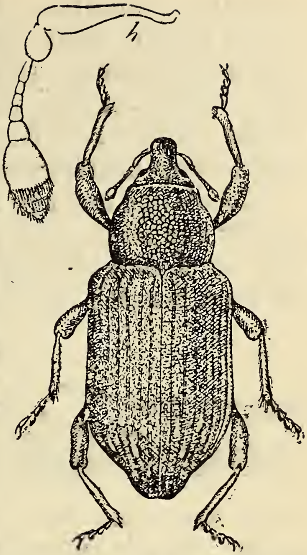


Fig. 23--*Lissorhoptrus simplex* adult enlarged, antenna more enlarged (After Tucker)

Emergence from hibernation begins early and ends late in spring. The earliest date known to the writer upon which an adult has been observed to be active was March 25. The latest date upon which adults have been found in hibernation was June 26. This gives a period of three months for the emergence of the entire generation of hibernating individuals.

The adult weevils are usually not noticed in spring until the first flooding of the rice fields. Then almost immediately they are to be found swimming about in the water among the rice plants or resting upon the leaves above water. Sometimes they rest upon the leaves apparently for hours, but when touched promptly "play possum", fall to the water and swim away. They appear to be equally at home either in or out of water. However, it is impossible for them to breed in any but water plants.

Dissemination from hibernating quarters probably takes place mostly at night. The writer has never observed weevils in flight during the day. He has observed them quite frequently flying to lights at night.

The first injury to the rice plant occurs upon the leaves and is done by the adult weevils, probably both prior to, and succeeding oviposition. This injury takes the form of longitudinal feeding scars, the weevil eating out a longitudinal furrow in the leaf, just as broad as the spread of the mandibles. Only the thin epidermis is left where the feeding is done. Little real damage is done in this way, but the work is very characteristic of this species.

Copulation and egg laying apparently commence shortly after the adults reach the flooded fields of rice. When ready to deposit an egg the adult female crawls down the rice stem beneath the water and surface of dirt to one of the principal roots. Here she inserts the ovipositor, apparently by merely forcing the tip of this organ through the epidermis of the root. The egg (fig. 24) is then placed longitudinally just inside the epidemis. The egg is cylindrical, pearly white, and about one thirty-second of an inch in length. It is three or four times as long as broad and is barely visible to the naked eye. The writer, with the aid of a binocular microscope has found as many as three eggs laid end to end, apparently through the same hole in the epidermis. In other cases only one in a place was found. The microscope failed to reveal any evidence of the use of the mandibles in making the hole in the epidermis for the insertion of the ovipositor.

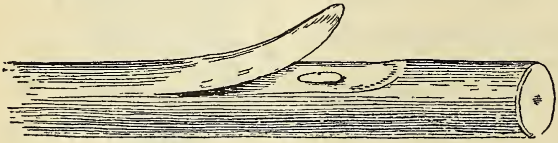


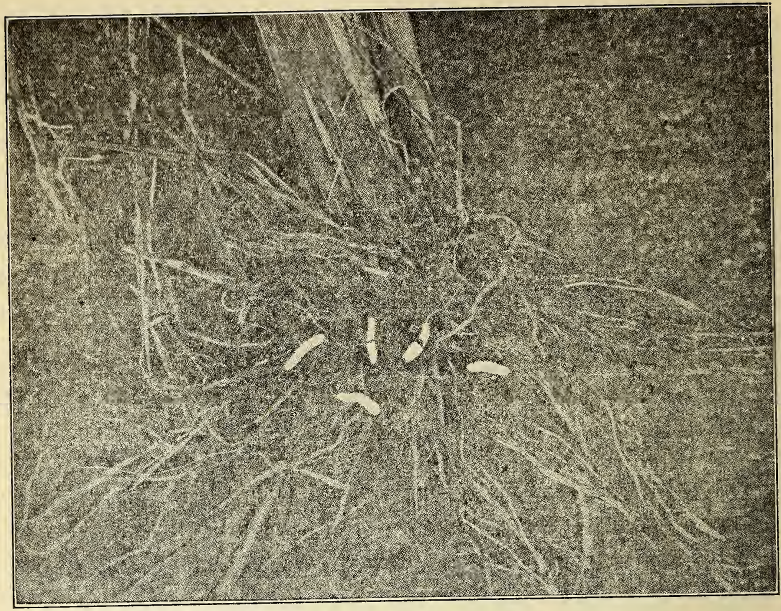
Fig. 24—Egg of Rice Water Weevil in section of rice root. The egg has been exposed by removing the epidermis of the root. Enlarged (original).

For the first few days of its existence the larva remains within the root in which it was hatched, feeding upon the inner root tissues and increasing in size. It advances along the root longitudinally, eating out a passageway as it goes. By the time it has exhausted the nutritive qualities of this first root, it is large enough to proceed farther and goes to another root undeterred by the surrounding mud. Whether it feeds little or much upon successive roots, practically all roots attacked are killed. Often several larvae are found among the roots of a single plant (pl. 13) and work great destruction there. At this stage many of the larvae are easily disclosed by pulling up infested rice plants and shaking the roots in water until washed clean of mud. Some larvae always float on the surface of the water, while others sink to the bottom. When the roots of a rice plant are severely injured the leaves turn yellow, and according to Tucker may even fall over upon the surface of the water.

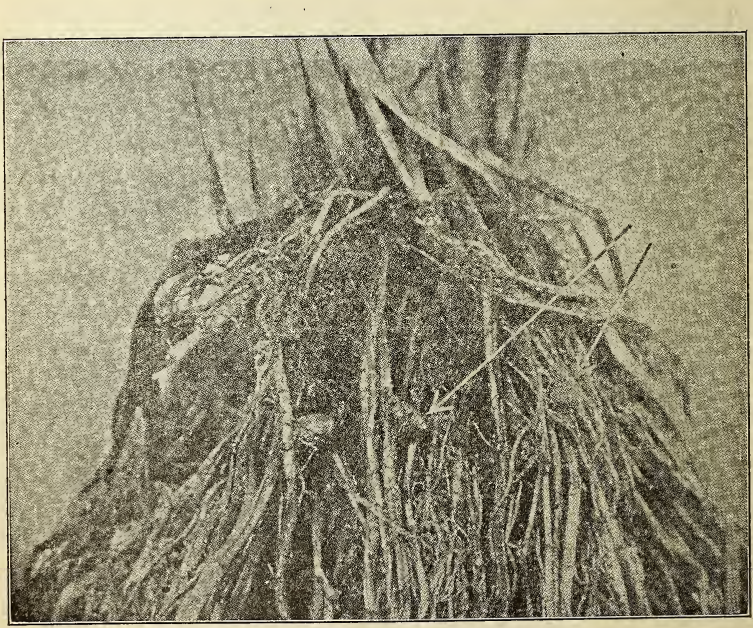
When full-grown, the larva is from one-fourth to one-half inch in length, very slender, and milk white. In preparation for the coming change, the larva gathers about itself an egg-shaped mass of dirt which it attaches to one of the healthy rice roots (pl. 13). The outside of this pupal cell is uniformly even and oval in shape. It would be interesting to know just how the larva accomplishes this result, but in the nature of things observations along this line were impossible. Within the pupal cell is a space from which water is excluded. Safe within this retreat, as if to make itself doubly secure, the larva spins a thin silken sac or cover about itself. The writer has found as many as fifteen pupal cells attached to the roots of one rice plant.

The pupa shows somewhat the form of the adult, but is entirely white like the larva. The duration of the pupal stage is probably from one to two weeks. When fully mature the adult breaks through the wall of the pupal cell, crawls up the root to which the pupal cell was attached, and so escapes to the open air.

The length of time the insect spends in each of these four stages is not definitely known. However, the time from deposition of the egg to the young adult stage in the spring has been approximately determined. In a plot of rice which was first flooded on June 1, 1912, the writer found a young adult in a pupa case on July 8, 1912. The egg could not have been deposited before the rice was flooded, and, supposing it to have been deposited the first day of flooding (June 1) the time occupied in reaching the adult stage by July 8 ,was thirty-eight days, or five and one-half weeks. It is, of course, possible that even less time than this was actually occupied by the insect in passing through the different stages.



Larvae of L. Simplex on Rice Roots.



2 Pupal Cases of L. Simplex in Natural Position on Rice Roots.

HOST PLANTS

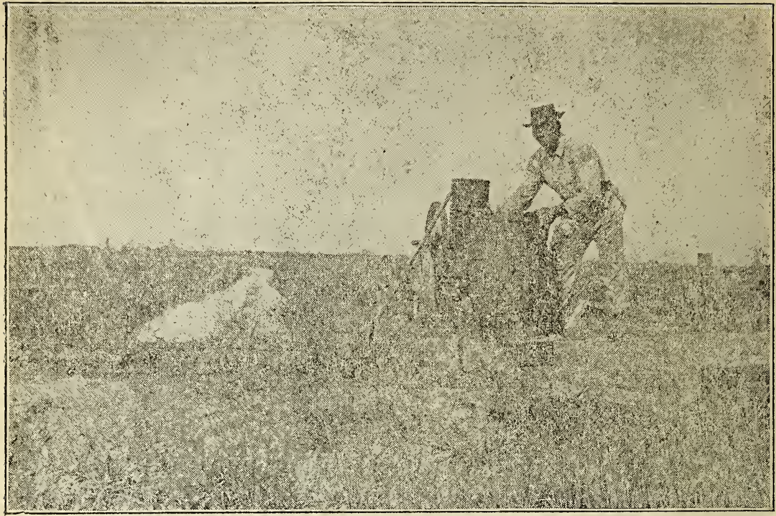
During summer of 1912, the writer conducted a series of cage tests to determine in what native grasses the rice water-weevil would breed. Different species of grass were transplanted to flat bottomed, galvanized pans. The roots were well covered with dirt and the pans then filled with water. They were kept filled with water above the dirt during the tests. Two pans were used in each cage. Sometimes only one kind of a grass was used in a pan, sometimes more than one. After the water was placed in the pans adult rice water-weevils were captured in rice fields and about one hundred weevils placed in each pan. After allowing ample time for the weevils to lay eggs in the roots of the different grasses, and for these eggs to produce larvae, the roots of each kind of grass were washed out in water to determine whether or not rice water-weevil larvae were present. The following species of grasses were found to be infested by the rice water-weevil: *Echinochloa zelayensis* H. B. K.,*Paspalum dissectum* L., *Paspalum boscianum* Flugge, *Syntherisma sanguinalis* (L) Dulac, *Capriola dactylon* (L) Ktze, *Axonopus compressus* (Sw) Beauv., *Panicum hiaus* Ell, *Panicum dichotomillorum* Michx.,*Jussioea suffruticosa* L., *Eleocharis obtusa* Schult.

The following species were found to be not infested: *Paspalum dilatatum* Poir, *Commelina* sp., *Diodia virginiana* L., and *Eclipta alba* (L) Hassk.

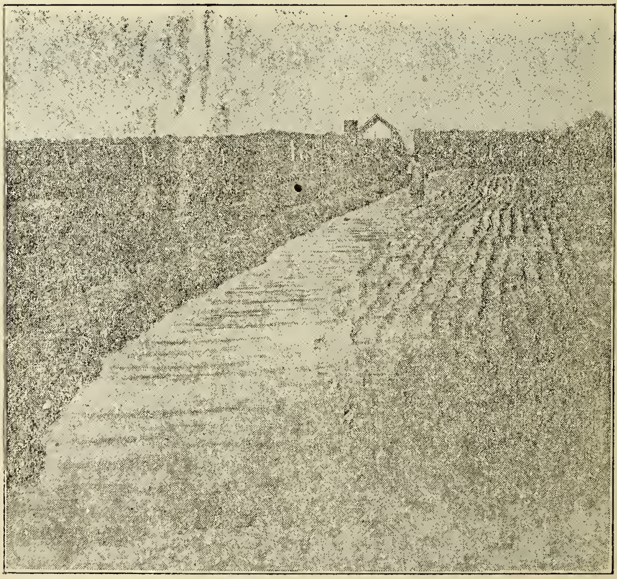
The following species were found to be infested in the field: *Paspalum larranagae* Arech., *Paspalum plicatulum* Michx., and *Cyperus flavicornus* Michx.

METHOD OF CONTROL

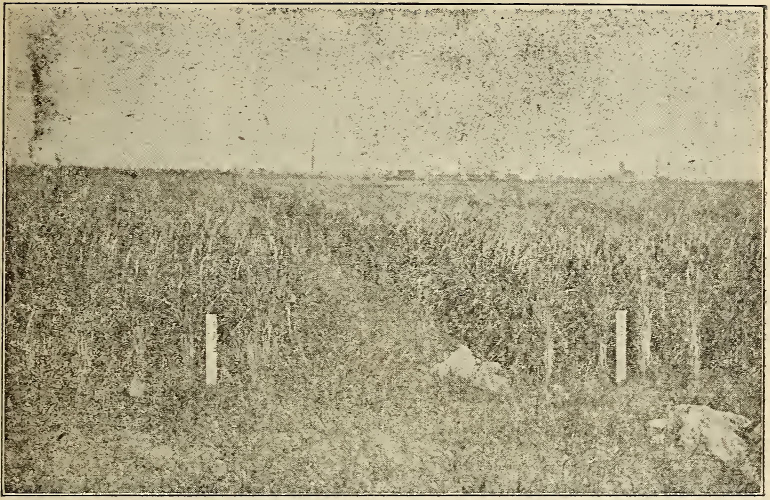
Careful experiments have demonstrated that drainage is still the safest remedy for the rice water-weevil. The proper time to commence drainage of the fields is from two and one-half to three weeks after the first flooding, while the larvae are still young. Drainage should continue for a period of two weeks. A shorter period of drainage will not kill the larvae, and a longer period will injure the rice. Farmers should not wait until the rice begins to turn



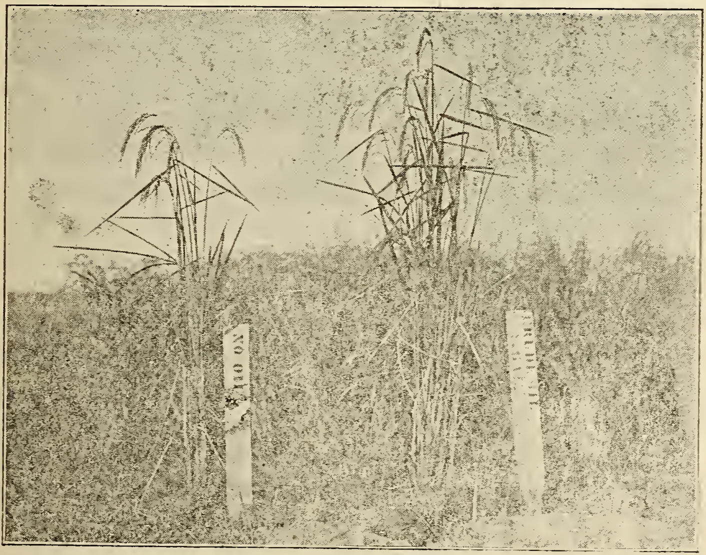
Applying Oil in the Irrigation Water to Prevent Root Maggots.



Oil at the Rate of 15 Gallons per Acre Was Applied
With This Irrigation Water.



Plot to the left was oiled at the rate of 20 gallons per acre. The plot to the left was not oiled. The oiled plot made 22.6 bbls. per acre and the unoiled plot made 16.8. Note the difference in the size of the stools.



Typical Plants from the oiled Plot and the Check. Note the difference in the size of the roots.

yellow before commencing to drain. The damage is practically all done by that time, and the rice needs water to enable it to throw out new roots and recover from the attack of the insect.

Subsequent experiments by the writer indicated that the conclusions drawn by Mr. Webb to be correct. It has been found that if the drainage method is used that the land should be drained two weeks from the time of the first flooding. The land should be allowed, if possible, to become completely dry. No injury is done at this stage of the plant growth if the ends of the leaves turn yellow to a certain extent.

The drainage method is advocated in all cases where rice is planted on new land or on land that contains a large amount of vegetable matter. It is necessary to drain land of this kind in order to prevent *straight head*; therefore, if it is drained two weeks from the time of the first flooding the first generation of maggots are destroyed. By this means the drainage serves two purposes.

The Use of Crude Oil to Prevent Maggot Damage.

An experiment in the use of crude oil for the prevention of maggot damage was conducted on the Experiment Station for several years, and the results seem to indicate that it is a cheaper and more effective method of combating the insect than the drainage method. This, of course, on land where there is no danger of *straight head.*

The weevil which lays the eggs which produce the root maggot was observed to feed on the leaves of the plant, to swim on the surface of the water, and to otherwise act in a manner not unlike the ordinary hard-shell terrapin. As a small amount of crude oil will cover a very large area with a thin film, it was thought possible that if the oil were applied to the water when the rice is first irrigated that the weevil would be prevented from reaching the roots to lay the eggs which produce the maggots, and the damage to the rice would thus be prevented; the results of the experiments seem to indicate that this is correct.

The data on an experiment in 1912 will be given as an illustration. A plot was oiled at the rate of 38 gals. crude oil per acre. Oil applied with first drainage and the water maintained through the growing season. No rice was killed by the oil. The yield per acre was 21.2 bbls. The check plot on this water maintained through the season with no oil made 14.8 bbls. per acre. Another plot oiled at the rate of 20 gals. per acre made 22.6 bbls. of rice per acre. The check on this made 16.8 bbls. per acre. Examination of the plants just before harvest showed that on the check plots the roots were badly injured by the maggot. On the oiled plots there was no damage to the roots that could be observed. A great many farmers in Southwest Louisiana have used oil with similar results.

It is believed that 15 gallons per acre is a good average application. The oil should be applied to the first irrigation water. Oil is not necessary in subsequent irrigations. The best way to apply the oil is to set a barrel or tank over the lateral or flume. By means of a valve allow the oil to run into the water at a rate which will apply the desired number of gallons of oil to the area flooded in a given time. It is easy to arrive at this if the capacity per day in acres irrigated of the lateral or pump is known. As rice is usually flooded the first time when the plants have two leaves and are about 5 inches high, care must be exercised that the water does not get so deep in the lower parts of the field that the leaves are floating on the surface of the water and consequently in the oil. The leaves which float on the surface in the oil will likely be killed. If the leaf is erect, the oil contact with even a large amount of oil is only the thickness of the oil film; consequently, no harm is done. If oil is to be used, the initial irrigation should be delayed as long as possible. One of the dangers in the use of oil is heavy rain and wind storms. If the rice is small and there is considerable exposed water surface, the wind may drive the oil to one side of the field where it will collect along the levee so deep as to destroy a considerable amount of rice. If the wind is accompanied by rain, the rain drops may spatter the oil on the leaves to such an extent that the rice will be injured. All of the oil experiments in 1917 were a failure due to a heavy wind and rain squall.

The oil used should be crude oil as it comes from the well. The lighter the oil the better it will spread on the surface of the water. Kerosene of low grade would probably be better than the crude oil. The heavy residue fuel oil from which the lighter oils have been distilled should not be used for this purpose.

The Stink Bug
(*Pentatomidae*).

This insect causes the Brown Spot of rice grains. The insect punctured the husk in order to suck the juice of the rice grain when it is in the milk stage. The fungi which obtains entrance to the grain through the puncture caused the black spot on the grain. The damage of this insect is greatest in the late varieties of rice. This is because the stink bug increases in number as the season advances. These insects are worse some seasons than others. Like other insects they seem to be numerous in cycles, probably because they are periodically checked by their natural enemies. So far as known there is no remedy for them.

RICE DISEASES.

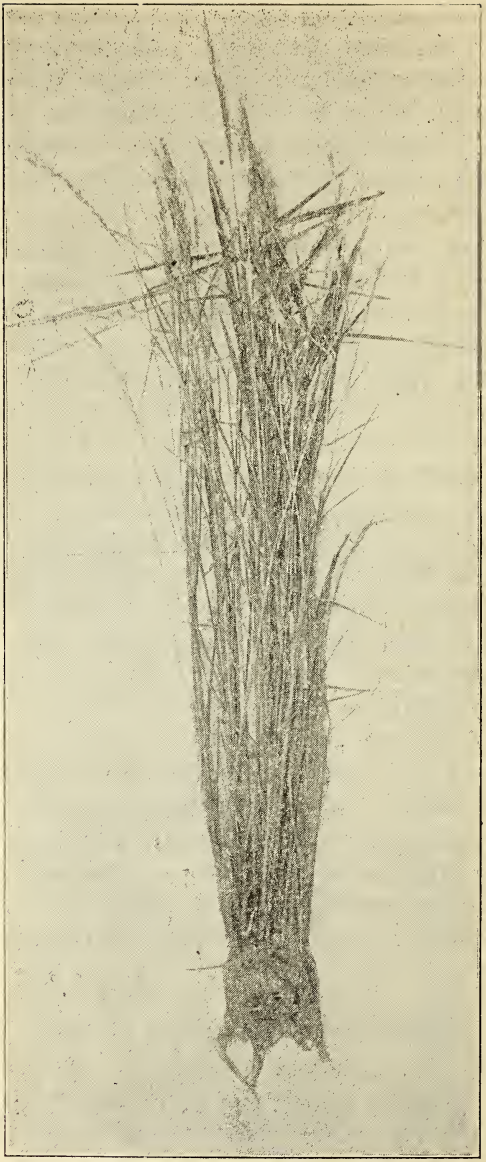
Rotten Neck (*Piricularia Oryzae*).

This disease gets its name from the fact that the most conspicuous lesions occur at the sheath nodes and at the region of the stem where it becomes the axis of the head. The first indication of disease is a dark spot on the "neck" of the head. This lesion causes a weakening of the stem so that the head breaks over at this point and hangs by the broken tissues. A wind or the reel of the binder will cause the head to fall to the ground and is lost. Another stage of the disease sometimes occurs when the plant is young—six inches to a foot high. At this stage the indications of the attack are brown spots on the leaves. These spots go entirely through the leaf. The spots enlarge and coalesce until practically the entire leaf is involved. The lower and older leaves of the plant suffer first, and become entirely brown and dry and shriveled; afterward the younger leaves are affected and the plant is apparently dead. In some instances, however, a small percentage of the plants the closely wrapped bud portion is unaffected, and the plant under proper conditions may send up new shoots and continue growing.

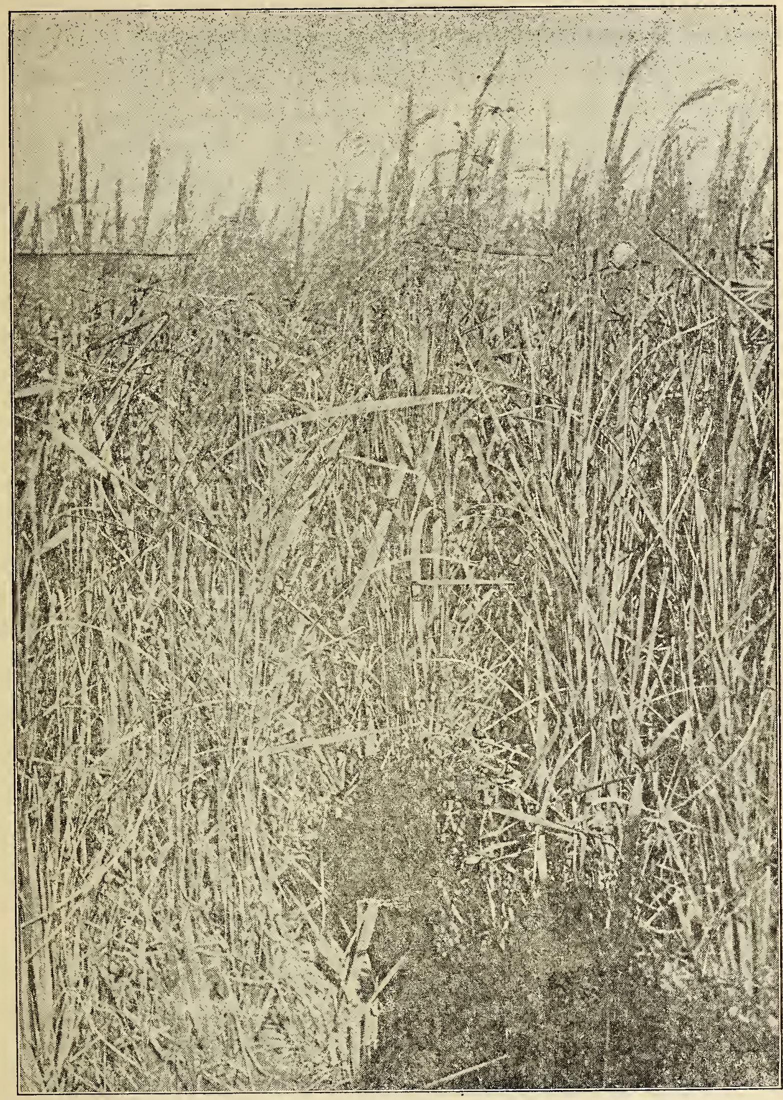
The most of the varieties grown in the Rice Belt of Louisiana seem to be immune to the disease in the heading stage. If the conditions are right, however, it frequently does considerable damage in the younger stage. The conditions under which it has been observed to occur in the younger stage of rice growth are extremely dry weather during June and early July. If the weather is dry during this period and the rice is not irrigated before the ground is wet by a rain, the chances are that the disease will develop. In 1912 and again in 1917 this disease destroyed a considerable amount of rice in Southwest Louisiana. The writer has seen as much as 50 acres which, with the exception of a few plants here and there which were apparently immune, was entirely destroyed. In every case the rice was late and had not been irrigated when the first July rain wet the ground. In 1917 there were fields which were entirely dead with the exception of irregular streaks through the field. These irregular areas of healthy rice were apparently caused by water which leaked through the levees from adjacent irrigated fields. There is not believed to be a great deal of danger from this disease in the early period of growth if the rice is properly irrigated.

Straight Head.

It is not known whether this is a disease or a condition brought about by physical causes. It seems to occur largely on land that has been cultivated the previous year to some highland crop and contains a large amount of vegetable matter. The writer has observed fields, which the year before had been planted to cotton, in which every cotton middle was marked out through the rice with



A STOOL OF STRAIGHT HEAD.



TYPICAL STRAIGHT HEAD

Straight Head. The rice between was a normal crop. In land which has previously grown lespedeza or cowpeas the Straight Head may occur in irregular patches.

The rice in which Straight Head occurs is generally unusually thrifty. It is well stooled, of good color, and gives every indication of a large crop. When the heads first appear there is nothing abnormal. The heads, however, fail to develop grain in the husk but remain straight and green for a time and then turn brown. If the plants are undisturbed and there is sufficient moisture in the ground, a branch frequently occurs on one of the lower nodes near the crown which produces a small head filled with normal grains.

From observations which have been made it appears that Straight Head does not often occur on fields which some time during the growing season have been drained and allowed to dry. Again it does not seem to occur on rice which is watered late and which may apparently have suffered to a certain extent from late flooding. Until more exact information is available it is considered to be safe practice on land which contains considerable vegetable matter to either irrigate late, or drain the land and allow it to become thoroughly dry once during the growing season. On land that has been in highland crops for several years it is advisable to follow this plan for the first two years that the land is planted to rice.

HOW TO GROW A CROP OF RICE

Outside of the rice growing sections there seems to be an idea prevalent in the popular mind that rice growing is a fearful and wonderful operation. The Stations receive a great many letters from people living outside of the Rice Belt who desire information as to how the crop is grown. Again, people from the North purchase rice farms and request of the Rice Station information as to how to plant the first crop. At it is impossible to answer questions of this kind in a comprehensive way by letter the following information is given. The statements which are here contained are based on experimental work, practical experience as a rice farmer, and upon the observed methods of some of the most successful rice planters in the Rice Belt.

Contour of Land and Soil.

In order to make use of modern machinery the water must be under control both with refernce to drainage and to irrigation. The land must be level enough so that the irrigation water can be conveyed through surface canals. By this is meant two embankments or levees with the water flowing between them and above the level of the land to be irrigated. By this means the water can be let out of the canal into fields or laterals by opening a gate in the levee. Canals and laterals should always be constructed on the top of ridges or follow the higher parts of the field in order that the water may flow from one contour check to the other until the lowest part of the field is reached. In this way all of the land will be uniformly irrigated.

Rice soil should be of very fine texture underlaid by an impervious sub-soil. A silt loam or adobe with a clay sub-soil is a good soil for rice; the former is preferable because it is not so sticky and therefore more easily worked. There should be little, if any, under-drainage.

The average silt loam soil contains enough sharp sand so that it does not stick or roll up badly on the implements if worked wet; even a very rusty plow or other tillage implement will soon scour and work well. On soil of this type plowing can be done if necessary when the land is wet and the harvesting machines can be run in the mud or even in several inches of water.

The adobe and what is frequently called the "hogwallow" type of soil is frequently found in the Rice Belt. A soil of this type cannot be worked successfully when wet. In order to be sure of a crop of rice on land of this type it is necessary to have the drainage under absolute control. This type of soil is usually stronger; that is, it will produce heavier yields of rice, and will hold moisture better during a dry planting season than the silt type of soil. One of the characters of the adobe soil is that when it is dry the surface checks forming particles about one-eighth inch in diameter. If handled properly, this character can be utilized as a mulch to conserve capillary moisture. Adobe soil is harder to plow; but if worked at the right time, the seedbed is easier to prepare than in the silt soil. Again, the seed may be planted in the adobe soil and irrigated to hasten germination. This cannot be done in the silt soil for the reason that the soil will pack around the seed and exclude the air, preventing germination.

Preparation of the Seedbed.

Plowing. On silt loam soils it is advisable to plow the land in the fall as soon as the previous crop is out of the way. Turn under all possible vegetable matter. Fall plowing permits the air to get into the soil and accelerates the decay of vegetable matter causing it to break down into ammoniates which is the only form of nitrogen that rice can use.

It has been demonstrated by the Hawaii Station that rice will not make use of the nitrate form of nitrogen. At the first thought this may appeal to us as being very strange because we know that all of our other farm crops use the soluble nitrates. Vegetable matter in breaking down in the soil forms ammoniates first which break down into nitrates, this being the form in which all farm crops other than rice make use of nitrogen, the most costly of all elements of plant food. The reason that rice makes use of the ammoniates and not the nitrates is that rice being a water plant must necessarily grow under conditions whcih do not favor the development of the nitrates. Ammoniates form in wet and badly drained soil and nitrates develop best in well-drained soil. Because of the above facts it is easy to see the advantage of fall plowing and the plowing under of all possible vegetable matter.

The rice roots penetrate to a depth of from eight to twelve inches. Large rice roots have been found seven or eight inches below the plowing. This being the case, it is advisable to plow as deeply as conditions will permit. There is no doubt that the common practice of plowing two and one-half inches in the Rice Belt is a mistake. On the other hand, it is not considered safe to plow deeper than six inches for the reason that harvest with the reaper will be difficult or impossible if the harvest season is wet or if it is difficult to completely drain the land. The lugs on the bull wheel of the binder must find hard ground or the machine will slip and the sickle will become choked with the tough green straw. These lugs always go deeper than the plowing if the land is soft. If a rice farmer contemplates plowing deeper than six inches, he should be prepared to equip his binder with a small engine in the event of a wet season.

The popular type of plow in the Rice Belt is the standard ten-inch two-bottom mouldboard gang with rolling coulters. The disc plow does not work well in the silt loam type of soil. Four mules will pull a ten-inch gang plow easily. The small tractor with a two or four-bottom gang is coming into popular use and is replacing the 40 and 60 h. p. tractors which were in common use a few years ago. The tractor probably will reduce the number of work animals used on the rice farm but it will not entirely replace them. Again the tractor will not work on wet land. It is better to plow land wet in the fall and turn under vegetable matter than to wait until the land is dry in the spring. If average rice land is plowed in the spring, it is necessary for rain to fall on it before it can be prepared for planting; therefore, if the season is very dry, the planting may be delayed. Fall and winter plowing, even though plowed wet, is easier to prepare than spring plowed land. This, of course, refers only to the silt loam type. The adobe soil should never be plowed wet, granting that this be possible.

Preparing the Seedbed.

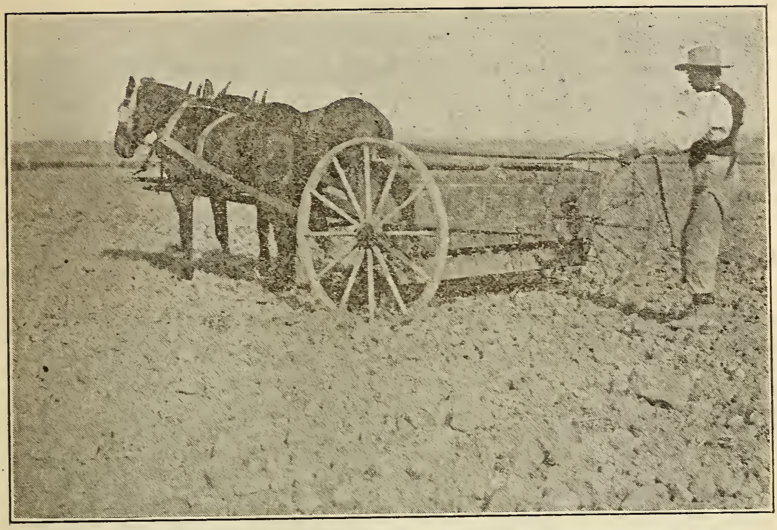
The amount of work necessary to prepare the seed-bed for rice depends upon the amount of vegetable matter or humus that the soil contains. The longer that the land has been planted continuously to rice the less humus there is; and, therefore, the more difficult it is to prepare the seed-bed. Because of its better physical condition due to aeration fall-plowed land is easier to prepare than land that has been freshly prepared in the spring. This was fully explained under "Plowing".

In preparing the seedbed the first implement used on the plowed land should be some form of clod crusher. For this purpose the two-section soil packer is probably the best implement that can be used.

The soil packer (see cuts) consists of a number of cast iron wheels "strung" or running loosely on a shaft. The rim of the wheel which comes in contact with the soil is "V" shaped. The entire set of wheels on the shaft presents the appearance of a corrugated roller. These sections of rollers are two in number fastened in a steel frame one section behind the other. There is a roller bearing at the end of each shaft. The corrugated or "V" rims break joints. In this way a hard clot which falls between the rims of the front section may not be crushed but merely pressed down in the soft earth. The rear section "breaking joints" with the front will crush the clod leaving the land completely pulverized on the surface. These machines are provided with a wooden box on the frame for the purpose of adding extra weight. The soil packer requires from two to four mules depending upon the condition of the soil. This machine may be used to advantage after the seed have been planted and again after the crop is up if the land is very dry. This machine is believed to be one of the best for the preparation of the seedbed that has ever been introduced into the Rice Belt.

A drag or "float" is also used for the same purpose. A float is constructed by nailing to any suitable frame six two by twelve planks from six to twelve feet long. The planks are laid clapboard fashion. Four mules are hitched to the side toward which the planks slant, sufficient weight is added, and the implement is dragged over the land.

A steel or concrete roller may be used for the same purpose, but neither the roller nor the float is as good as the corrugated soil packer for the reason that the former packs the soil leaving a smooth surface which gives up moisture readily. The latter leaves the soil in corrugations



Spreading commercial fertilizer broadcast. The plowed land should be disced prior to spreading the fertilizer.

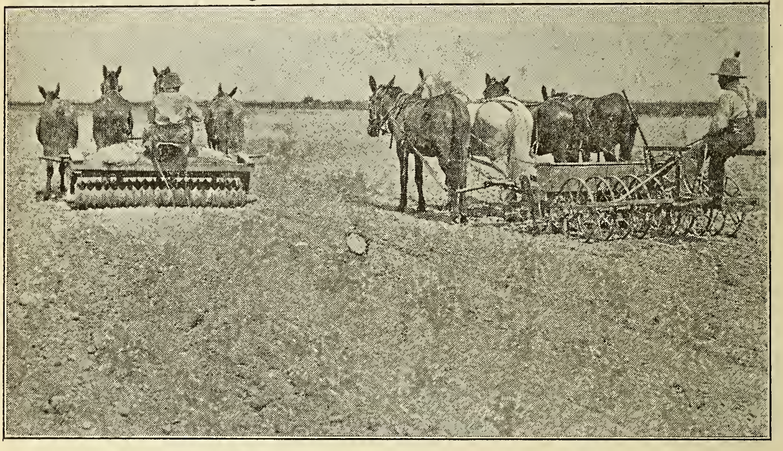
The Float is a good implement for preparing the Seedbed.

which are full of small surface checks by which the capillarity is broken and the loss of moisture prevented.

The soil packer is followed by a disc harrow. It is usually necessary to disc the land from two to four times.

The disc is followed by the drag or spike tooth section harrow. This should be used from one to three times. This may be followed by the soil packer. The land should now be ready for planting.

The tractor is very useful in the preparation of the seedbed. For this purpose it is believed that the small



Preparing the Seedbed with the Land Packer, and Drilling Rice.

Harvesting a 20-bbl. Crop of Rice.

tractor is more desirable than the large for the reason that the 60 h. p. machine tends to pack the land like a steam roller, and it is believed materially reduces the yield of rice.

Planting.

The seed may be planted with the grain drill on land prepared as heretofore indicated or it may be sown broadcast on the disced land and harrowed in with the drag harrow.

About 90 per cent. of the rice in the United States is planted with the drill. The drill plants the seed in rows from six to eight inches apart and at a uniform depth. The drill may either be plain or have a fertilizer attachment. The drill also may cover the seed by five or six links of chain or rings which drag behind the shoe or disc or it may have press wheels. There are two types of drill in common use, each of which have certain advantages. These are the disc and shoe type. It is not necessary to go into a detailed discussion of the relative value of the different types, and it will be sufficient to say that the most popular drill is the combined fertilizer and seed, with discs and press wheels. The seed should go through a small shoe at the back of the disc which will insure all of the seed being at the same depth in the soil. Where there is no shoe the seed merely dropping into the furrow as it is opened by the disc, a part of the seed will be near the surface and part of them in the bottom of the disc furrow; again, if the soil is moist enough so that a little will stick to the back of the disc the seed will be thrown out of the ground. The press wheels are a great advantage for the reason that the soil being pressed tightly over the seed will hasten germination in very dry soil. As a matter of fact, seed will germinate when planted with the drill in land that is too dry to possibly sprout rice planted broadcast. The drill will save at least twenty pounds of seed per acre. From sixty to seventy pounds of seed per acre is used in drilling. From eighty to one hundred are used when the rice is sown broadcast.

The broadcast method of seeding is employed when the land is too wet to make use of the drill. It is usually only necessary to double-disc the land before broadcasting. The wagon end-gate seeder or the box seeder with a wheel at each end are the implements in common use.

It will be noted that broadcast rice is only thinly covered with soil; therefore, it cannot be of a uniform depth. Some of the grains which fall in depressions or disc marks will be covered with two or more inches of dirt while others will be merely covered. In a field which is planted broadcast some plants will be found with two leaves while others are just pricking through the surface. As much as ten days will elapse between the appearance of the first and last plants. As the greater number of seed are covered thinly with soil, it is very easy for the rice birds to pull the young plants. If they can get the plants out of the ground, the Purple Grackle, or large rice bird, will continue to pull the plants until they are three inches high. The drill, on the other hand, packs the soil over the seed so that the birds have considerable difficulty in pulling the plant so that the seed will come up with the stalk. The stalk will break off and the seed and root will be held by the soil which is packed over them.

After planting, furrows for drainage should be opened through the low parts of the field with a plow or middle-burster. This is for the purpose of draining the land in the event of a heavy rain and again when it is desired to drain the land for harvest. If water stands on the land before the seed germinates, there is danger of loss of stand. If the rice has commenced to germinate however, and if the seed is not too deep, it will come up to a good stand.

Irrigating land in order to germinate seed is not advisable on the silt loam soil of the Rice Belt. The reason for this is that the land is of so fine a texture that it is necessary to completely cover the land with water in order that the entire field be wet. In other words, if two trenches be made ten feet apart in the planted field and filled with water, the soil would not wet over two feet on each side of the trenches; about half of the space would be dry. In the adobe type of soil the water would go through the soil from one trench to the other. In the adobe soil, therefore, it is possible, and it is the common practice, to irrigate to germinate the seed. This is not a safe practice on the silt loam types.

Fertilizing Rice Lands.

The two most important factors in successful rice culture are fertilization and irrigation. Unless the fertility of the soil is maintained through the proper use of fertilizer or by means of crop rotation, together with the use of some of the more important elements of plant food, profitable yields cannot be maintained. It should be remembered that it is easier to keep up the normal fertility of the soil by the constant application of plant food than it is to build up a soil that has been allowed to become impoverished through neglect. It should be remembered also that because of the expense of fitting up a farm for rice production yields should be maintained for the longest possible period of time, because rice being a water plant will thrive on land that is too low to grow other crops undess considerable money is expended in drainage. The drainage of rice lands so they will grow highland crops will cost almost as much as the irrigation of rice. On new land, therefore, profitable yields of rice should be maintained for at least eight and possibly ten years before the land is drained and planted to highland crops. It is of course understood that water to the amount of at least sixty acre-inches must at all times be available in order to produce a crop of rice.

Fertilizer Requirements.

It may be stated almost without exception that rice soils are deficient in phosphorus.

Rice requires level land near an abundant water supply; therefore, rice growing is restricted largely to the level coastal plain having numerous streams or underground water, or to the level bottom lands of some of our great rivers. Land of this kind is largely formed by sediment brought down by the streams from the higher lands above.

Such land in every case is rich in nitrogen, and it almost always contains an abundance of potash, but the phosphorus content is generally very low. The chemical analysis of most rice soils shows merely a trace of phosphorus. However, the phosphorus they do contain must be in a highly available form, being probably of animal origin, or no crops could be produced. As soon as this supply of phosphorus is exhausted there is a marked decrease in the yield of rice. It is therefore safe to say that all rice soils will require, sooner or later, the application of some form of available phosphorus in a chemical fertilizer.

Applying the Fertilizer.

Commercial fertilizer may be applied broadcast on the prepared land before sowing or drilling the seed, or it may be placed in the soil with the seed, making use of the combined rice drill and fertilizer distributer for the purpose.

If the fertilizer be applied broadcast, it should be spread on the disced land so that the harrow, soil packer, etc., in the preparation of the seedbed will mix it with the soil. If the fertilizer is underneath the surface of the soil, no amount of rain will wash it out. If, however, it is on the surface, a heavy rain may wash away a considerable amount of the available material.

The machine used for spreading commercial fertilizer broadcast is similar to the ordinary broadcast seeder. Instead of the fluted feed in the bottom of the hopper there are large plate fertilizer distributers. One of these machines will fertilize a strip ten feet wide and apply from 25 to 3,000 pounds of fertilizer per acre. These machines are sometimes called lime spreaders because they are used also for that purpose. They will spread any finely divided material.

If there are no weed and grass seed in the soil, there is little difference, so far as the effect of the fertilizer is concerned, between the broadcast method of application and where the fertilizer is placed in the row with the seed. During the growing season the plant roots interlace across the row and gather all of the plant food required. As a matter of fact the rice roots generally penetrate to a depth of ten inches or more and will consequently absorb any soluble material that may be present. There is, however, this important factor to be considered. Acid phosphate seems to accelerate the growth of water crabgrass and other water weeds almost as much as it does rice; consequently, in the case of drilled rice the grass and weeds which grow between the rows may retard the growth of the rice.

The combined seed and fertilizer drill is constructed similar to the ordinary seed drill. There is another compartment in the rear of the seed hopper having in the bottom fertilizer distributers and tubes from same to the shoe of the drill. In the combined drills which are on the market at the present time the fertilizer and the seed are conducted through the same tube to the shoe; consequently, the seed and fertilizer are placed in the ground together. If not over 200 pounds per acre of fertilizer is used, and if the land is moist, there is no danger of loss of stand. However, if the land is very dry, as is frequently the case during the rice planting season, the seed will germinate before the acid of the fertilizer becomes diluted by the soil moisture; in such a case there is some danger of loss of the stand of rice. It is believed that there should be a separate tube to conduct the fertilizer to the heel of the shoe or disc so that the fertilizer falls in the furrow as it is closing behind the shoe or disc. In this way the fertilizer will be placed below the surface of the soil in the row with the seed where it will do the most good but not in contact with the seed. It would seem that the fertilizer would then be in a position to stimulate the rice plant first and aid it to grow faster than the weeds and grass which germinate between the rows of rice.

From observation the following is a good rule to follow. If the fertilizer is to be spread broadcast, the seed should be sown broadcast. The reason for this is that the fertilizer is distributed evenly through the soil. The plants from the broadcast rice develop as individuals. They are not crowded in the row as is the case of the drilled rice; consequently, the plants have more room to stool or tiller and have a better opportunity to crowd out the grass. As has been mentioned before, however, there must be just the right amount of moisture in the soil in order to be sure of a stand of broadcast rice.

Rice Irrigation.

Rice may be irrigated in three ways: (1) The water pumped from streams; (2) the water pumped from wells; (3) tide-water irrigation.

The greater part of the rice raised in the United States is irrigated by pump from streams or lakes. The water is lifted from the stream by large centrifugal pumps to a surface canal by which the water is conducted to the fields through smaller canals or laterals. Some of these canals in the Rice Belt are 150 feet wide and from 25 to 30 miles long and irrigate as much as 25,000 acres of rice. One of the canals in the Belt has pumping capacity of 215,000 gallons per minute.

In the greater part of the rice-growing area it is possible to irrigate from deep wells. These wells are from 8 to 14 inches in diameter and from 125 to 350 feet deep. On a good well there should be at least 75 feet of screen in waterbearing sand or gravel. The water in a well of this kind rises within a few feet of the surface of the ground. If the water level is below 50 feet from the surface of the ground, it does not pay to pump the well for rice irrigation. The impellers of the centrifugal pump should be at least 10 feet below the normal water level of the well. A good well equipped with a pitless pump and from 40 to 75 horse power plant should furnish from 2,500 to 4,500 gallons per minute and have a capacity for at least 300 acres of rice.

Tide irrigation can be used only on land adjacent to freshwater streams where the tide causes the water to rise each day at least six inches above the level of the land to be irrigated. At low tide the water is below the level of the rice fields. A levee or embankment is constructed along the bank of the stream. There are automatic gates in the levee which control both the irrigation and the drainage.

When the water is high and it is desired to keep the land dry, the gates are not opened except at low tide. When the rice is to be irrigated, the gates are opened at high tide and closed at low tide. When the rice is flooded the gates are closed. A very small part of the rice growing area of the United States is irrigated in this way.

Canals and Laterals.

The main canals and laterals consist of two embankments or levees between which the water runs. The level of the water in the canal is always above the surface of the land to be irrigated. There are gates in the levees of the canals to distribute the water to the fields. Main canals and all laterals should follow highland or ridges in order that the water may be conducted from one field to another by gravity. The proper depth of the water in the field is governed by check levees which may be straight, making rectangular fields, or they may follow the contours of the land.

Field Levees.

There are two methods of making field levees. The one is to make square fields. The size of the fields is governed by the contour of the land, but usually ranges from 2 to 20 acres. They are constructed with a small road grader or with a plow and a "V"-shaped implement called a pusher which follows the plow, pushing the furrow to the top of the embankment under construction. No rice is planted on these levees, and they are not plowed or worked over with other implements. The disadvantage of this type of levee is that weeds and red rice will grow on it, and it offers a harbor for the muskrat and other animals which burrow holes which causes loss of water and other damage to the crop. Again it is necessary to cut a "road" by hand around all of the levees when the rice is ripe and ready for harvest. This for the reason that the bull wheel of the binder will not run in the levee ditch without slipping and it will not run on the side of the levee.

The second method is to build contour levees. The contour levee is a crooked embankment which follows the contour of the field. By the use of this form of levee it is possible to maintain the water at a uniform depth of from 2 to 5 inches. The location of these levees may be established by instrument or by water level. If the water method is used, the water is turned on the field and when the water is 3 or 4 inches deep in the lowest part of the field a line of stakes is set on the points in the field where the water ranges one inch in depth. The embankment is made by following the line of stakes with a plow. The other contour are staked out in a similar manner. Levees of this type are low and wide. They are usually made by plowing together from four to six furrows with a walking plow. By plowing up about three times the levee is made. This should be done before the rice is planted. If the levees are made after the rice is planted, the instrument must be used in laying them off. These levees are prepared and planted as a part of the field. The rice will grow almost to the top of the levee; consequently, there is little if any land wasted. In plowing, planting, harvesting, etc., the implements work over the levees as a part of the field. Time is saved in being able to go a longer distance without turning, and it is not possible for weeds and grass to grow or animals to find a harbor on levees of this kind.

When to Irrigate.

The proper time to irrigate depends upon the variety, the season, and the time that the rice is planted in the spring.

If the season is normal, that is if there is enough rain to keep the land moist, water should not be applied until the rice is about six inches high. The plants should be high enough to shade the ground to a considerable extent so that the water will not become too hot which may result in the checking of the growth of the young plants. It may be, however, that the land is infested with weeds and grass so that it may be necessary to flood earlier. If the weeds and grass are to be destroyed,the water must be turned on as soon as the weed seed germinate. On land known to be very weedy, it is well to flood with at least five inches of water as soon as the rice has developed two leaves. In this case all of the rice plants are covered with water. Within 24 hours the rice leaf will "stretch" to the surface and float. The water must be maintained at a constant level until the plant develops sufficiently to stand alone without the support of the water. It is easy to understand that if the water is turned off too soon that the plant which has been forced to grow six inches in 24 hours to keep from being drowned is not strong enough to stand without the support of the water. The first leaf which comes to the surface dies as soon as other leaves have developed. In normal irrigation the water should be turned off and the land allowed to become dry fourteen days from the time the first water is put on. The second flooding should be done when the plants show the need of it, and the water should be maintained until the rice is ready to drain for harvest in the fall.

As soon as all of the heads have turned down in the fall, the land should be drained. When the land should be drained depends entirely upon how rapidly the water will run off when the levees are cut. If the drainage is good, the water will run off rapidly; and if the rice is not far enough advanced, injury may result. Where the drainage is good the water should be held on longer than when the drainage is bad. This is a matter in which the farmer must exercise his judgment and for which no fixed rule can be laid down. The idea is to secure a dry field for harvest and at the same time not injure the quality of the rice by draining too soon.

Highland Rice.

Oryza Sativa is a water plant. The roots secure air after the manner of the reed family through tubes in the outer leaves; therefore, there is no such thing as a true highland rice of this species. It is true that any rice will grow well if planted in rows and cultivated like corn up to the heading season. If the rains make the ground very moist while the rice is heading and filling, a fair crop may result. Under the best possible conditions, however, not over half the yield may be secured on "highland" that can be obtained on irrigated rice. It may be profitable to grow rice in this way for home consumption, but it will not pay from a commercial standpoint.

Harvesting Rice.

Harvesting rice should begin as soon as the heads are well filled and commence to turn down, or when the grain is past the milk stage. This depends upon the season and the contour of the land. If possible the land should be dry when the crop is cut. It is better to cut a good crop in the mud than a light crop on dry land because the water is turned off too soon.

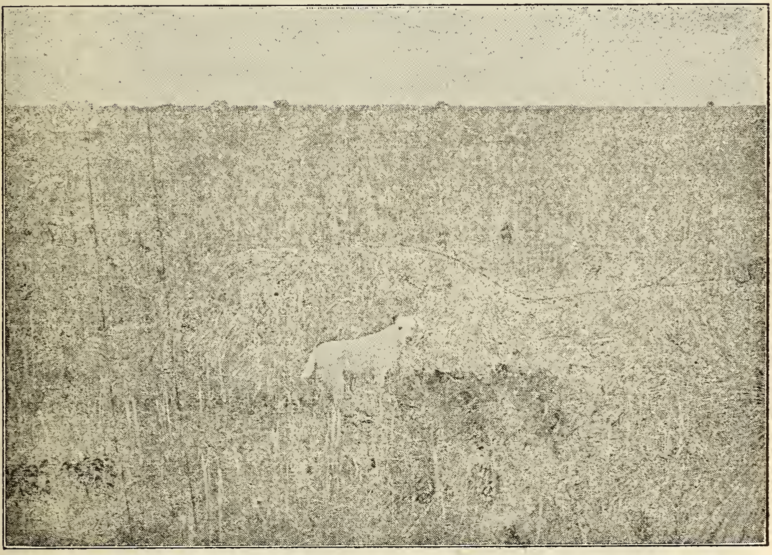
While there is considerable rice cut by hand with the reap hook, by far the greater part of it is cut with the self binder.

The binder is very similar to the grain binder; the principal difference being in heavier construction and lugs on the bull wheel. Both the bull wheel and the grain wheel are cased with galvanized iron. This is to prevent mud from being carried up by the rim and spokes and clogging the machinery. The lugs are long enough so that the bull wheel will get traction on any rice land no matter how wet it may be. The straw of rice when cut is very green and heavy; therefore, the construction of the machine must be very heavy.

Six or seven mules are required to pull a rice binder. If the binder is equipped with a gasoline engine, from three to five mules are required. A binder will cut from 4 to 10 acres per day depending upon the crop and the condition of the land. Rice should not be cut while the dew is on it, or if it is wet from rain.

Shocking.

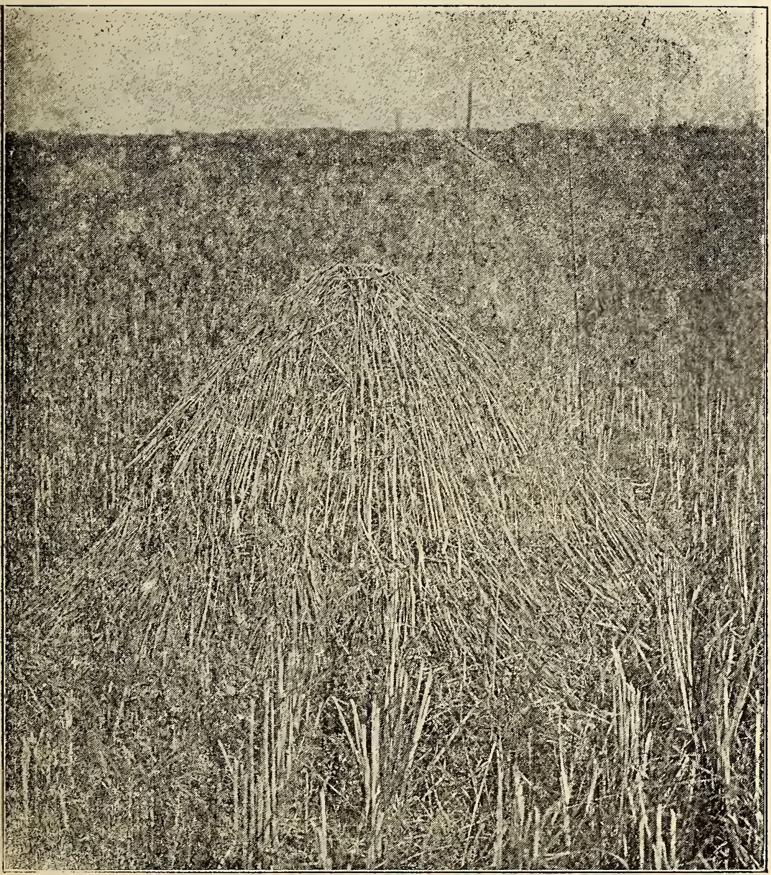
The bundles should be placed in shocks as soon as cut. A shock consists of from 10 to 20 bundles. The bundles should be set closely in the shock at the base in order to prevent the shock from twisting as the straw becomes dry. The cap consists of from one to two bundles and is the most important part of the operation. As little rice as possible should be exposed to the sun. Rice which is exposed to the sun dries out too rapidly and many of the grains check or "suncrack" which causes them to break in milling, thus reducing the yield of best grade clean rice. It is believed that the best method of shocking is the small shock with the single cap bundle. It is possible to construct a shock of this kind with little if any grain exposed. If the large shock is used, with the double cap, all of the rice on the last cap bundle placed will be exposed to the weather; therefore, the last cap bundle should be placed on the south side of the shock with the heads turned to the north.



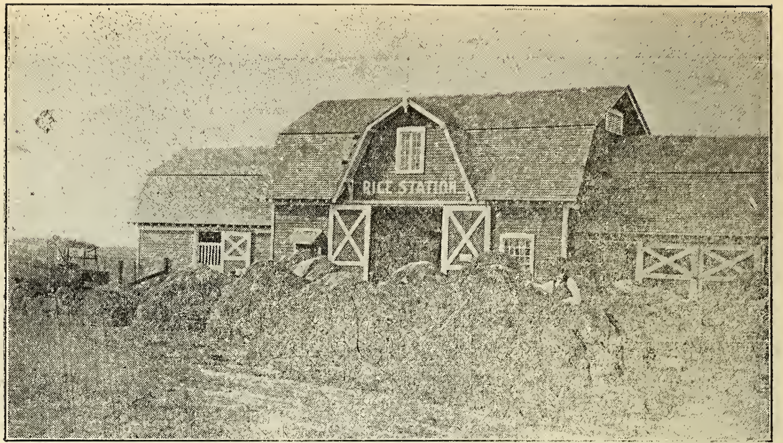
Badly shocked Rice is not profitable in any season. In a wet season it means a heavy loss.

Note the Sprouts on the top of this Shock.

A well-shocked field of Rice. Note the small shocks, single caps, and no exposed grain. Rice exposed to the sun will dry too rapidly and check and "sun crack".



A shock like this is easier to build than a bad shock. The grain in a shock of this kind will keep for several months if the water does not stand around the base of the shock.



The bundles of these "hand stacks" were wet to the band when put up. The butts of the bundles, being exposed to the air, dry out in a short time so that the rice can be threshed without damage. It is advisable to use the hand stack when the season is bad. The cost is about eight cents per bag.

Handling Harvested Rice During a Wet Season.

It sometimes happens during the harvest season that excessive rains occur making it impossible to harvest and thresh rice without a certain amount of loss. If the water should stand around the base of the shock for a considerable length of time, the base of the bundle becomes saturated and sometimes rotten. The grain is well protected in the husk and will not sprout in cool weather unless it is completely covered with water. In the case of wet and rotten butts the rice should be hauled by wagon or on a slide to a high land and placed in a hand stack. The hand stack is made by first making a shock of the dry and cap bundles. A small stack is built on the shock. In this stack all of the wet portion of the butt end of the bundle is exposed to the sun and air. The stack is built up as high as a man can reach from the ground. When the straw is dry and the grain through the sweat the rice may be threshed. The cost of hand stacking is small. By means of the hand stack rice can frequently be saved in good condition when otherwise a large per cent. would be lost.

In some cases the weather is such that the grain in the shock is dry and ready to thresh but the butt of the bundles is so wet that the thresher will not handle it. In a case of this kind the wet portion may be cut off. This is accomplished by making a broad axe-like implement having a handle three feet long. The bundle is laid on a block of wood and the wet end is chopped off with one blow of the tool. These knives or choppers can be made out of old plow shares sharpened and fitted with a handle. A machine has been improvised for more rapidly handling the rice than by the hand-chopping method. The machinery of a mower with the blade attached is run with a binder gasoline engine or other convenient power which operates the sickle at a rapid rate. The blade is supported in a horizontal position with the fingers up at a convenient distance above the ground. By dropping the bundle on the blade the wet portion is cut off almost instantly. This machine is a great time and money saver when there is a large amount of wet rice to be cut.

Threshing.

There is little difference between the rice threshing machine and the wheat thresher. The rice thresher should have more separating capacity than the wheat machine and speed should be less in order that as small a per cent. as possible of the rice be hulled.

The rice, both straw and grain, should be dry and crisp when threshed. If the weather is very dry, it is possible to thresh as soon as the rice is cut. But this is not advisable for the reason that the grain contains considerable moisture which will collect in the sack after the rice is placed in the mill or warehouse and cause it to heat or mould. It is not advisable to thresh rice until it has been in the shock for at least two weeks. Stacked rice should not be threshed under thirty days from the time of stacking.

In the United States rough rice is handled largely in jute sacks which will hold from 162 to 200 pounds each. The unit of measurement of rough rice in Louisiana is the barrel of 162 pounds, in Arkansas the bushel of 45 pounds, and in California the sack of 100 pounds. The latter is by far the most convenient and should be universally adopted. The bushel or any other measurement of odd pounds should be discarded for the decimal system.

COST ESTIMATES IN RICE GROWING.

Following is an estimate of the cost of producing an acre of rice. The method of calculating each item is given in detail.

It is believed that the estimate given is high for the present year and may be applicable to the coming year when cost of materials will probably be higher. It will be noted that 200 acres of rice are being produced on a 400-acre farm entirely with mule power. There is no doubt but that a tractor would decrease the cost of planting operations. No engine is used on the binder which would cut down the cost of harvest. Six dollars per acre is charged as water rent which on a 10 bag crop is not far from average but is higher than water would cost pumped from a well. Prior to the war water could be pumped from a well of 3,000 gal. capacity using coal for fuel for from $3.75 to $5.25 per acre, depending upon the rainfall during the summer months. The well owner gets the advantage of the usually heavy summer rains. Interest and taxes on the land not planted in rice but used for pasture is charged to the rice crop, but $3 00 rent on pasture is deducted from the cost per acre of growing rice. Cattle and other livestock are a source of revenue and should be used to reduce the cost of producing the rice because the cattle will convert red rice and other unsalable by-products of the crop into a very high-priced product. Again, it is entirely possible to produce corn, peas, sorghum, and oats on the land not in rice, all of which are revenue producers and materially reduce the cost of rice production. These are not given consideration in this estimate which is made on a basis that the farm is producing nothing but rice and pasture. One-half of the automobile expense is charged to the rice because the car is ordinarily used at least half of the time for other business and pleasure which cannot be charged to rice. The farmer on a 400-acre farm is considered the manager. The profits of the business represent his salary.

Mule Cost.

A mule may work on a rice farm about 200 days out of the year. He will eat 18 lbs. of corn and 25 lbs. of straw per day, or its equivalent, for 10 months. This will amount to 194.7 bu. of corn and 3.75 tons of straw. The corn at $1.50 per bu. and the straw at $4.00 per ton will equal $157.05 for feed. Pasture and green feed will amount to $2.00. A harness to last five years with repairs will cost $18.00 or $3.60 per horse per year. $4.00 for vaccination and other medicine and shoes. The mule is worth $200.00 and will last 8 years. Deterioration $25.00 per year. Total cost per year of $191.65. If the mule works 200 days, the cost per 10-hour day is therefore 96 cents per mule.

Plowing.

A gang plow is worth $75.00 and will last 5 years; repairs paint shed room $20.00. Deterioration will be $15.00 per year. It will plow, including summer plowing, 150 acres per year. The plow cost is then 13 cents per acre.

Discing.

A disc harrow will cost $50.00 and will last 5 years. Repairs will be $15.00. It will prepare about 150 acres per year. The disc cost per acre will equal about 6½ cents. About 3 double-discings will be required.

Harrowing.

Will cost $15.00; will last 10 years; repairs $4.00. Harrow cost per acre about 12 cents.

Corrugated D. Section Land Packer.

Cost $60.00; will last 5 years; repairs $15.00; covers 12 acres per day; per acre cost 7½ cents.

Fertilizer and Seed Drill.

Cost about $140.00; lasts 10 years; repairs, etc., $40.00; cost per acre to drill 9 cents.

Maintenance and construction of levees, 50 cents per acre.

Labor, $1.50 per 10-hour day.

Binder Cost.

Will cost $200.00; repairs $100.00; will last 7 years and cut about 150 acres per year. Cost per acre 30 cents.

Miscellaneous.

Threshing 30 cents per bag. Hauling to market 10 cents. Warehouse and insurance 10 cents. Every rice farm should have at least $500.00 worth of tools in a well equipped shop. We find many farms with machinery to the extent of $5,000.00 or more and a tool equipment of less than $10.00. In this estimate tools will be charged at yearly interest on the investment.

How Cost Estimate Is Made on an Acre of Rice.

Plowing. Four mules and one man will plow four acres per day. Man at $1.50; mules at 96 cents each; plow 13 cents per acre. Plowing will cost $1.46 per acre.

Discing. One man and four mules at a cost of $5.34 will double-disc six acres per day (three double-discing are usually required to prepare seedbed; disc cost 12 cents. Cost per acre for three double-discings $2.68.

Harrowing. One man and four mules will single-harrow 15 acres per day (two harrowings required). Cost per acre 89 cents.

Pulverizing or Rolling. Four mules and one man will roll or pulverize 10 acres per day at a cost of $5.34 which will equal 54 cents per acre.

Drilling. Four mules and one man will drill about 8 acres per day, which will cost about 68 cents per acre.

Fertilizer. Two hundred pounds of 16 per cent. acid phophate per acre; cost per ton $28.00; per acre $2.00.

Weeds and Red Rice. Pulling weeds (Coffee and Mexican to prevent either getting a foot-hold) and red rice $1.00 per acre.

Harvesting. One man and seven mules will cut about seven acres per day. Man $1.50; mules $6.72; binder 30 cents; oil 10 cents; total $8.32 per day or $1.19 per acre. Two shockers at $1.50 each is 42 cents per acre. Twine, 5 lbs. at 20 cents, $1.00. Total cost of cutting and shocking one acre of rice, $2.81.

Cutting Roads Around Field. Two men will cut around about 15 acres per day. Cost per acre 20 cents.

Threshing.

Ten bags at 30 cents equals $3.00 per acre.

Hauling to market, insurance, and warehouse, each 10 cents; $2.00 per acre.

Itemized Cost of One Acre of Rice Estimated From Above. 1917-1918.		Estimated Cost 1910
Plowing	$1.46	$1.26
Discing	2.68	2.13
Harrowing	.89	.28
Pulverizing	.54	.30
Drilling	.68	.20
Fertilizer	2.00	1.40
Seed	2.50	1.66
Weeds and Red Rice	1.00	.75
Levees and Maintenance	.50	.40
Cutting Roads	.20	.18
Harvesting	2.81	2.25
Threshing	3.00	3.00
Hauling	1.00	1.00
Warehouse and Insurance	1.00	1.00
Water Rent	6.00	6.00
Shop and Tools	.20	.20
One-Half Automobile Expense	.50	.40
Telephone	.07	.07
Insurance	1.20	1.20
Fencing	.10	.08
Taxes	.62	.50
Interest on Investments	3.00	3.00
Total	$31.95	$27.26

INVENTORY.

400 acres land and improvements	$20,000.00
10 mules at $200 each	2,000.00
10 sets harness at $15	150.00
2 Gang Plows at $75	150.00
2 disc harrows	100.00
1 walking plow	20.00
1 pulverizer	60.00
I drill combination fertilizer	140.00
1 binder	200.00
1 levee plow	50.00
1 lever pusher	25.00
2 scrapers	10.00
2 wagons and beds	160.00
1 shop equipment	500.00
One-half automobile expense	200.00
1 farm fan	35.00
1 platform scale	25.00
1 wagon scale	100.00
1 end gate seeder	15.00
1 manure spreader	125.00
1 feed grinder	50.00
1 12 h. p. engine	400.00
1 buggy and harness	125.00
1 driving and saddle horse	175.00
1 saddle and bridle	25.00
1 lot forks, shovels, and odd implements	15.00
1 lot doubletrees	15.00
Typewriter stationery, desk, fire-proof safe	300.00
Total,	$25,170.00
Interest on investment at 6 per cent	1,051.20
Less pasture 150 acres at $3.00 per acre	450.00
	$601.20

As stated, farm accounting is difficult and friendly criticism will be welcome with reference to the above.

Attention is again invited to the fact that in the above estimate, irrigation from well is not considered, no tractor is used, no binder engine is used, revenue is not considered from the by-products of rice fed to livestock, and no consideration is given to oat pasture that may be grown on rice land during the winter. Other crops may also be grown for the reduction of feed expense.

NOTE. It should be noted that the figures showing estimated costs are for the years 1910 and 1917-1918 and do not apply to conditions in 1920. The reason for this apparent discrepancy is that the publication of this bulletin was deferred at the time on account of insufficient funds.

Louisiana Bulletin No. 173 March, 1920

Agricultural Experiment Station

of the

Louisiana State University and
A. & M. College

Baton Rouge

The Clarification of Cane Juice Without Chemical Treatment

By

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Louisiana State University
and
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PREFACE.

The investigations discussed in this article form a continuation of the work previously published in Bulletins 161 and 165 of this station, on the use of vegetable decolorizing carbons in the cane sugar industry.

The writer again wishes to express his indebtedness to Mr. W. G. Taggart, Assistant Director of the station, without whose active cooperation this work would have been impossible to accomplish. He also gratefully acknowledges the advice received from other members of the staff, and from Mr. W. L. Owen. His special thanks are due to Mr. S. Byall, who carried out a large part of the analytical work, as well as to Messrs. S. R. Asuncion and Octavio Cabral de Vasconcellos, who likewise assisted him in the laboratory.

"This paper was presented before the Sugar Section of the American Chemical Society at the 59th Meeting, held at St. Louis, April 12 to 17, 1920."

THE THEORY OF CANE JUICE CLARIFICATION.

The clarification of beet and cane juices is generally considered to be an essentially chemical process, even though most people admit a secondary "mechanical" effect.

The object of clarification manifestly is the removal of as large a quantity as possible of all impurities, especially of those which impede the obtaining, by evaporation and crystallization, of the largest quantity of pure cane sugar. The fact that this object has so far been almost entirely attained by the use of very active chemicals naturally would lead to the conclusion that clarification is a chemical process.

The oldest method of purifying cane juice is the application of heat. This agent has two advantages. In the first place it prevents the decomposition of the sucrose which would otherwise take place under the influence of enzymes. But the use of heat at the same time constitutes a clarification process, as may readily be observed when cane juice is brought to the boiling point. A flocculent precipitate separates out and the liquid itself clears up considerably. However, clarification by heat alone is not practical from the sugar making standpoint, because it is impossible completely to separate the precipitate from the liquid by decantation or filtration. The next step, undertaken about 1200 years ago, was the use of caustic lime, and this chemical is up to the present day the only substance used in all the different methods of sugar manufacture. The first object of the addition of lime to beet or cane juice is to neutralize the natural acidity of the juice which would otherwise at high temperatures convert the sucrose into invert sugar. However, it should be stated right here that, at least as far as beet juices are concerned, the danger from inversion is very slight, as was found long ago.[1] Next, the lime forms insoluble compounds with some of the acids in the juice, both inorganic and organic, and also with certain proteids and gums. When this precipitate is formed, it "envelops," as is generally said, solid particles suspended in the juice, such as clay adhering to the cane when it enters the mill, finely divided fiber, etc. But the difficulty we have just mentioned in connection with the clarification by heat alone is not entirely overcome by the additional use of lime. It is a well known fact that even here the separation of precipitate and liquid cannot be effected by ordinary filtration, because any filter used will soon clog and stop running. For this reason factories using lime alone must resort to decantation. Having thus removed the greater part of the liquid, it is possible to recover the remainder by filtration in presses, but even this is a slow process. Although the clarified juice appears reasonably clear to the naked eye, the sugar obtained is dark and of such a quality that it must be refined before entering consumption channels. All this shows that in spite of the comparative clearness of the juice something has been left in it which keeps us from getting a high quality sugar. It is therefore not surprising that attempts have been made to improve on the lime process, and these improved methods which are largely employed in practice, have again been worked out from purely chemical considerations. It was observed that an excess of lime would cause more precipitate to form, and therefore had a greater purifying action. However, in the first place, so much lime is introduced by this process that the excess must be again removed, before separating precipitate and liquor. This may be done by neutralizing the excess lime with some acid which forms insoluble lime salts, such as carbonic, sulfurous, or phosphoric. All of these three may be, and at least the first two are extensively used in beet sugar manufacture, and also to some extent with cane. It is a fact that with these improved methods of clarification the precipitate can be separated much more easily from the liquid than is the case when lime alone is used for clarification. Juices treated with a large excess of lime and neutralized again with carbon dioxide can readily be filtered through presses, and while this is not directly possible when sulfur dioxide or phosphoric acid are used for neutralizing the lime, nevertheless the precipitate settles much better, or the liquid can be decanted more easily, and the filtration of the mud is also greatly facilitated. In Louisiana the processes just described, however, offer great difficulties for another reason, and that is because our juices generally contain large quantities of reducing sugars which at high temperatures are acted upon by the free lime under the formation of very dark colored compounds; thus the very object of clarification would be nullified by introducing more impurities than we had to start with. This disastrous effect of an excess of lime can be overcome by not heating to high temperatures before neutralization, but methods based on this fact have not found favor here, because it would necessitate very careful temperature control.* But in this dilemma we are helped by the most remarkable and important fact that the same result which is obtained by first using lime and then acid may also be gotten by reversing the whole process, first adding the necessary quantity of acid to the juice, which can be done in the cold, and then neutralizing with lime. In practice, only sulfurous and phosphoric acid can be used in this reversed process, because only very little carbon dioxide will dissolve even in cold cane juice. These are then the methods we can use in Louisiana. Phosphoric acid is employed only to a slight extent, on account of its high cost, while practically all of our sugar houses use sulfurous acid. It must be admitted that this reagent exerts a chemical effect on certain constituents of cane juice, especially on the coloring matter. The latter is bleached, but it must be strongly emphasized here that the bleaching does not mean removal, but simply a conversion of the coloring matter into compounds with little or no color. Even this effect is not permanent, however, as on exposure to the air the bleached compounds darken again. The excess sulfur dioxide also precipitates a certain amount of proteids and gums, but they would be precipitated by lime alone also, and besides, a part of the precipitate redissolves upon liming. We see therefore that the chemical effect of the sulfur treatment is not of very great importance either.

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[1] Wohryzek, Chemie der Zuckerindustrie, Berlin, 1914, p. 306.

The question may now well be raised whether cane juice clarification by the methods just described is really an essentially chemical phenomenon.

Some experiments made by Noell Deerr[2] throw considerable light on this question. He found that of the total impurities precipitated by heat and lime only 28% were removed by the lime, while the other 72%, or by far the greater part, were thrown down by heat alone, and could even be removed by filtration of the cold juice through an asbestos filter. Norris[3] also showed

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*In the Battelle process (Intern. Sugar J. **15**, 47, 535) the cane juice is boiled with a large excess of lime, and the destruction of the glucose is carried so far that the coloring matters formed at first are again destroyed. In this way the cane juice is converted into a liquid resembling beet juice, and is then treated like the latter, by carbonatation.

[2] Intern. Sugar J. **18**, 559 (1916).

[3] Intern. Sugar J. **21**, 71 (1919).

that upon passing cane juice, from which all the coarser particles had already been removed by screening, through Chamberlain filters a large quantity of material was retained on the filter, especially in the case of juice from the last mill where the greatest pressure is applied and which delivers juice of very low purity. Now, the 28% of impurities precipitated by the lime, which in itself is a small quantity, may only in part consist of chemical compounds of lime. Even admitting that it does so entirely, it is readily seen that the so-called ''mechanical'' effect of clarification is much more important than the purely chemical one. This conclusion is further strengthened by the fact to which we have already directed attention, that filtration of the juice becomes possible only when a large quantity of finely divided precipitate is produced in the juice and, what is more important, that it does not matter much how this precipitate is produced, whether by adding lime first, or acid first. Nobody certainly would claim that if we had to do with a purely chemical process it would be immaterial whether we treat first with acid or first with alkali. All this leads us to the inevitable conclusion that the ''mechanical'' side of clarification is infinitely more important than the chemical effect.

This being so, the next question is, what this mechanical effect consists of and by what forces it is brought about. The above mentioned experiments of Deerr and of Norris give us a clue in this respect also. Since the impurities precipitated by heat can be removed also by filtration in the cold through specially prepared filters, they are evidently not molecularly dispersed, but in a more coarsely dispersed state. Since they pass through ordinary filters at least for a time, they are probably colloidal. During the last few years evidence has been accumulating that the whole subject of cane juice clarification should be reinvestigated from the standpoint of colloidal chemistry. Prinsen Geerligs[4] probably was the first to call attention to this. He says in substance: ''The general aim of the different methods for making high grade sugars is the obtaining of a clear, and if possible of an uncolored juice; and of these two the first desideratum is of foremost importance, the color dissolved in the juice not being so objectionable as floating or suspended dark substances.'' Further on down he says: ''The clarification of cane juice by chemicals does not eliminate from the juice any great amount of impurities, but it is more the improvement of the physical properties which is effected, as for example the removal of the small amount of colloidal matter which hinders the juice from being filtered and keeps afloat the suspended ingredients;'' and again ''Although the quotient of purity should be ascertained daily in the raw and clarified juices, the increase in the figure should not attract any undue attention and on no account should it be used as a criterion for the value of one system or other of clarification for white sugar manufacture.'' Schneller[5] also showed that certain phenomena connected with cane juice clarification should be viewed from the standpoint of colloid chemistry. Only a year ago Peck[6] published an article giving a short outline of what had been done on this subject and made a plea for further investigations.

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[4] Practical White Sugar Manufacture. London 1915, p. 62-3.

Unfortunately we know very little as yet about the colloids in cane juice. Undoubtedly we have to do with a very complex system, in which the dispersion medium is evidently water. Some of the solutes are in a state of molecular dispersion, for instance sucrose, dextrose, levulose and various ash constituents. Others are colloidally dispersed, such as proteids, polyphenol compounds and related coloring matters, clay, very fine particles of fiber. Then there are also coarse dispersoids, like larger particles of soil and of fiber. Between all of these constituents adsorption complexes are probably formed, which further complicate the situation. Noel Deerr[7] seems to be the only one who has subjected cane juice to a colloid-chemical analysis, and he states that the colloids are lyophilic, charged negatively, irreversible as regards the effect of heat, and reversible in their behavior towards alkali. This information probably takes into account only a part of the colloids present. Here is then an interesting field for investigation.

However, we already have a sufficient number of data to suggest the true nature of the ''mechanical'' effect of clarification, and by what forces it is brought about. The fact that of all the ''chemical'' processes of clarification those are the most effective, where a large quantity of finely divided precipitate is formed in the juice, the manner of producing it being unimportant, leads to the suggestion that this effect is due to surface phenomena. There is no doubt that mutual precipitation of colloids and electrical phenomena also play a part, but anyway, both of these are known to be closely associated with surface energy. This theory based on colloidal chemistry permits us to explain the different observations made in connection with the various methods of clarification described above.

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[5] Louisiana Planter **56**, 44 (1916).
[6] Intern. Sugar J. **21**, 70 (1919).
[7] Intern. Sugar J. **18**, 502, 558 (1916).

When cane juice is filtered cold through filter paper or cloth, it passes through at first and the filtrate is cloudy. The colloidal particles are smaller than the pores of the filtering medium, and they go through. But the particles are quickly adsorbed by the filtering medium, and the pores get clogged. The filtration soon becomes very slow, although successive portions of the filtrate are clearer and clearer. If pressure is applied, the colloid particles are again partly driven through the pores, but as soon as the mat becomes thick enough, filtration stops once more. If the juice is heated before attempting filtration, the colloids form larger aggregates, and when the juice is now poured on a filter, the first part of the filtrate is clearer than is the case in cold filtration. But even the larger aggregates of the colloids are non-rigid, soon clog the pores, and filtration stops again. Now, if we use lime in addition to heat, this reagent forms some insoluble lime salts consisting of rigid particles, some of which are at least large enough to be retained by the filtering medium. These particles of lime salts adsorb a part of the colloids, in proportion to their active surface. They also serve now as filtering medium, and it is not surprising that a clearer filtrate is obtained, and that more filtrate can be recovered. But the quantity of rigid particles is not sufficient to adsorb all the colloids, and to form a medium sufficiently porous for the liquid to pass readily. In the sulfitation process a much larger quantity of finely divided precipitate is produced than with lime alone, adsorption is increased, and the filtration proportionately facilitated. In the carbonatation process the amount of precipitate is still larger, and here we reach the possibility of perfect filtration, where the colloids are adsorbed to a maximum extent, and where there is a sufficient number of rigid particles to form a porous filtering medium.*

If the adsorption theory is correct, it should be possible effectually to clarify cane juices by simply introducing into them chemically inert, finely divided substances of consequently high adsorbing power. If such a process is feasbile, it will not only be a strong theoretical argument in favor of the adsorption hypothesis, but would also offer great practical advantages. We have already mentioned that the carbonatation process is not favored in Louisiana on account of the danger from the excess lime, and that the sulfitation process gives very imperfect results, because it does not remove a sufficient quantity of colloids, and particularly of coloring matters. This line of reasoning led us to investigate the applicability of chemically inert adsorbents as filtration aids.

CHEMICALLY INERT ADSORBENTS AS CLARIFYING AGENTS.

A great number of such adsorbents have, from time to time, been proposed for use in the sugar industry.[8] Among these are bone black and other carbons, various forms of silica, clay and similar silicates, gypsum, dolomite, sawdust, paper pulp, peat, bone meal, brick dust, pumice stone, etc. But of all these only some of the various forms of carbon and of silica have so far been found to be of practical value.

Bone black is extensively used in the refining industry; the application of modern decolorizing carbons has been the subject of several of our publications during the past few years.[9] The primary effect of these carbons is due to adsorption; it may in certain cases, however, be followed by chemical phenomena, such as the one mentioned on page 13.

The use of a small quantity of a good decolorizing carbon added to hot cane juice has such a purifying action on it that it can be readily filtered and emerges as a water white liquid. This in itself would constitute a satisfactory clarification process provided that no sugar were lost by inversion. But even if the process were safe from this standpoint, it would not be practical. Decolorizing carbons are quite expensive, and the success of their use in the factory depends on the number of times they can be used over and over again, with or without revivification. Now, if carbon is used on raw juice, it will not only adsorb the highly dispersed solutes in it, but will also become contaminated with all the coarser dispersoids, like particles of soil and fiber, which have passed through the juice strainer. This is liable to decrease its adsorbent effect on the highly dispersed solutes, and also makes it more difficult to revivify the carbon for repeated use. It is exactly this consideration which led to the use of these carbons on juice previously clarified by one of the chemical methods.

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* Another interesting application of adsorption to the clarification of cane juice is found in the Williamson defecator, where the dispersoids and the air introduced into the juice form adsorption compounds of low specific gravity. These rise to the surface and are easily removed.

[8] Deutsche Zuckerind. **34,** 9 (1909).

[9] La. Bulletin 161 and 165; La. Planter **58,** 381; **59,** 154.

But, fortunately, this pretreatment of the juice, which is necessary for practical reasons, can be effected just as easily by a chemically inert adsorbent as by chemical methods, at the same time avoiding the drawbacks of the latter, mentioned before. It has been found that properly prepared Kieselguhr answers all the requirements.

The use of this material in the sugar industry was patented in 1886 by Heddle, Glen and Stewart in England, and by Wiechmann in the United States,[10] for the filtration of refinery liquors, 1 to 3% being used. In 1893 Soxhlet patented a process[10] in which one part of Kieselguhr with two to three parts of sawdust is used, also for filtering refinery liquors. Shortly after 1900 Kieselguhr was also introduced into processes of sugar manufacture directly from the beet. Various patents were taken out[11] in which Kieselguhr was advocated as a clarifying agent in addition to chemicals, and the principal advantage claimed was that the amount of lime used could be reduced, on account of the purifying effect of the Kieselguhr. Others admittedly recommended the Kieselguhr simply to facilitate the filtration of clarified juice or filter press mud, and for this purpose Kieselguhr has for a number of years been employed in the cane sugar industry.[12] Fribourg[13] states that the juice obtained by sulfitation or by clarification with di-calcium phosphate can be filtered through presses with the aid of Kieselguhr. Bachler[14] recommends the addition to the juice of clay or similar colloids, which are then coagulated by the addition of another colloid, like protein, or by acidifying with phosphoric acid; Kieselguhr is then added to increase the filtrability of the precipitate. A similar process has been patented by Krieger.[15] In other processes the Kieselguhr is used in a similar way as in the preparation of dynamite, that is as a medium which absorbs large quantities of liquid. Thus Bachler[16] incorporates hydrogen peroxide with it, and uses this preparation for the decolorization of cane juice. Wayte[17] absorbs phosphoric acid in the Kieselguhr and uses the mixture for clarification; Tiemann[18] "mordants" the Kieselguhr with such chemicals as stannous chloride, followed by neutralization with sodium hydroxide for decolorizing the juice.

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[10] Newlands and Newlands: Sugar. London 1909, p. 586.

[10] Loc. cit.

[11] Z. Ver. D. Zuckerind. **49**, 481; **55**, 484; **56**, 90; **57**, 401, 533, 692; **58**, 887. (1899 to 1908).

[12] See also Peck, Intern. Sugar J. **20**, 322 (1918).

[13] Intern. Sugar J. **19**, 162 (1917).

In all the processes just mentioned it is not expressly stated that Kieselguhr may also be used without simultaneous treatment with chemicals, but this idea readily suggests itself and may have been had in mind by at least some of the authors cited above. It is actually claimed as a new process by Wooster.[19] The use of Kieselguhr without chemicals was also suggested to us last year by Dr. J. Sauer. This, and the theoretical considerations outlined in the first chapter of this bulletin, led us to investigate the possibilities of Kieselguhr and decolorizing carbons, singly and combined, for clarification, omitting chemical treatment altogether.

THE EFFECT OF KIESELGUHR AND OF DECOLORIZING CARBON ON MILL JUICES.

The first question to be settled was whether there is any danger of inversion when Kieselguhr or carbon are used on raw juices, without first reducing its natural acidity. On theoretical grounds it would be expected that there is less danger of inversion than from the sulfurous acid present in juice made by the white sugar sulfitation process, because the latter acid has a greater inverting power than the organic acids in cane juice itself. In our experiments on this problem we used Filter-Cel, which is a specially prepared form of Kieselguhr of great efficiency as a filter aid, and Norit which is a highly active decolorizing carbon.

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[14] Intern. Sugar J. **18,** 386 (1916).
[15] Intern. Sugar J. **20,** 577 (1918).
[16] Intern. Sugar J. **17,** 292 (1915).
[17] Intern. Sugar J. **16,** 294 (1914).
[18] Z. Ver. D. Zuckerind, **64,** 52 (1914).
[19] U. S. Patent No. 1, 304, 458 (1919).

A quantity of raw cane juice was boiled under reflux in the presence of ¼, ½, and 1% of Filter-Cel. Samples were drawn every fifteen minutes and analyzed. It was found that the acidity of 10 cc. of juice was reduced 0.1 to 0.2 cc. N/10, owing either to the presence of alkaline substances in the Filter-Cel, or more probably to adsorption. Upon plotting the sucrose figures against the time intervals, a curve was obtained which is concave towards the time axis, and which shows that the rate of inversion is not constant, but increases steadily with the time. During the first half hour of boiling it is very slow, and the total drop in sucrose amounts to 0.1%. If it is considered that in practice the juice would not be boiled for any length of time, but simply heated to the boiling point, or not even quite to that, then rapidly filtered and evaporated in the effects at low temperature, it becomes clear that the danger from inversion is not very great. Nevertheless, the glucose ratio must be carefully controlled. At any rate, the natural acidity of the juice can easily be reduced, if desired, by the addition of a small quantity of lime or other alkaline substance, in order further to lower the hydrogen ion concentration.

Similar experiments with Norit showed that 1% of this carbon added to raw juice reduces the acidity 0.5 to 0.6 cc. N/10 per 10 cc. of juice, evidently owing to adsorption. It is therefore not surprising that the rate of inversion becomes extremely low, as soon as Norit is added. Inversion can be detected by the drop in the Clerget figures only after two hours boiling. There is indeed a constant increase in the reducing effect on Fehling's solution, but since the fall in the Clerget value is nil, this is probably due to a secondary chemical effect of Norit on some constituent of the juice.

Having ascertained that there is little danger from inversion in actual practice, we next made some clarification experiments in the laboratory in order to see what purifying effect Filter-Cel and Norit have on raw cane juice.

The Filter-Cel was added in quantities of ¼, ½, and 1% on the weight of the mill juice, the latter brought to the boiling point, and filtered through a Buchner funnel. With 1% of Filter-Cel the juice passed through the funnel in 3 to 5 minutes, with ½% it required 20 to 25 minutes, and with ¼% about 3 hours. This shows that the rate of filtration increases rapidly with an increase in the quantity of Filter-Cel. The most economical quantity would have to be determined for each particular case and factory. The filtrates were quite clear, but dark in color; in other words the colloids are not entirely removed. Large scale factory tests in this state, which we shall mention further on, have demonstrated that clarification with Filter-Cel alone is fully equal to sulfitation. However, we are not satisfied with a process just as good as those used, and therefore followed the Filter-Cel treatment by one with Norit, at the rate of 1% on the weight of the juice.

Complete analyses were made of all the juices, and the results are given in Table I. Since different juices were used in these tests, we have calculated all the results on the basis of 100 parts of total solids, and of 100 parts of sucrose, in order to make them comparable.

TABLE I

On basis of 100 parts total solids

	Sucrose	Glucose	Ash	Org. non-sugars	Acidity
Experiment 1					
Raw Juice..............	83.11	7.81	2.48	6.60	0.98
¼% Filter-Cel..........	83.51	7.56	2.45	6.48	0.94
1% Norit...............	84.59	7.60	2.48	5.53	0.64
Experiment 2					
Raw Juice..............	79.43	10.76	2.78	7.03	1.05
½% Filter-Cel..........	80.46	10.72	2.71	6.11	0.95
1% Norit...............	80.68	10.75	2.69	5.88	0.76
Experiment 3					
Raw Juice..............	84.77	7.27	2.56	5.40	0.93
½% Filter-Cel..........	84.90	7.15	2.43	5.52	0.92
1% Norit...............	85.23	7.27	2.46	5.04	0.62
Experiment 4					
Raw Juice..............	80.99	10.70	2.62	5.69	1.08
½% Filter-Cel..........	81.10	10.68	2.53	5.69	1.00
1% Norit...............	81.60	10.71	2.53	5.16	0.69
Experiment 5					
Raw Juice..............	81.80	9.87	2.58	5.75	1.09
1% Filter-Cel...........	81.97	9.89	2.47	5.67	0.99
1% Norit...............	82.42	9.81	2.47	5.30	0.76
Experiment 6					
Raw Juice..............	86.46	4.90	2.45	6.19	0.93
1% Filter-Cel...........	87.36	4.95	2.30	5.39	0.87
1% Norit...............	87.99	4.93	2.34	4.74	0.64

TABLE I—Continued

On basis of 100 parts total solids

	Sucrose	Glucose	Ash	Org. non-sugars	Acidity
Experiment 7					
Raw Juice..............	85.02	7.09	2.40	5.49	0.92
1% Filter-Cel...........	85.41	7.15	2.27	5.17	0.84
1% Norit...............	85.71	7.20	2.31	4.78	0.63

On basis of 100 parts Sucrose

	Total Impurities	Glucose	Ash	Org. non-sugars	Acidity
Experiment 1					
Raw Juice..............	20.32	9.40	2.99	7.93	1.17
¼% Filter-Cel..........	19.75	9.05	2.93	7.77	1.12
1% Norit...............	18.21	8.98	2.93	6.70	0.76
Experiment 2					
Raw Juice..............	25.89	13.55	3.50	8.84	1.32
½% Filter-Cel..........	24.28	13.32	3.37	7.59	1.18
1% Norit...............	23.95	13.32	3.34	7.29	0.95
Experiment 3					
Raw Juice..............	17.97	8.57	3.02	6.38	1.10
½% Filter-Cel..........	17.79	8.42	2.87	6.50	1.08
1% Norit...............	17.33	8.53	2.88	5.92	0.73
Experiment 4					
Raw Juice..............	23.47	13.21	3.24	7.02	1.33
½% Filter-Cel..........	23.30	13.17	3.12	7.01	1.23
1% Norit...............	22.55	13.12	3.11	6.32	0.85
Experiment 5					
Raw Juice..............	22.25	12.06	3.15	7.04	1.33
1% Filter-Cel...........	22.00	12.07	3.01	6.92	1.21
1% Norit...............	21.83	11.91	3.00	6.42	0.92
Experiment 6					
Raw Juice..............	15.67	5.67	2.84	7.16	1.08
1% Filter-Cel...........	14.47	5.67	2.63	6.17	1.00
1% Norit...............	13.65	5.60	2.67	5.38	0.73
Experiment 7					
Raw Juice..............	17.61	8.33	2.82	6.46	1.08
1% Filter-Cel...........	17.08	8.37	2.66	6.05	0.98
1% Norit...............	16.67	8.40	2.70	5.57	0.74

If we average the different results, we find that ¼% of Filter-Cel (one experiment only) gave a purity increase of 0.40, ½% one of 0.42, and 1% one of 0.49. The additional increase in purity due to the use of 1% of Norit averaged 0.50. The total purity increase is therefore 0.9 to 1 point. The table below shows how the different constituents of the juice contributed to this purity increase. The changes, marked with the — sign for decreases, and with the + sign for increases, are calculated in % of each constituent present in the raw juice.

TABLE II

	Glucose	Ash	Org. non-sugars	Acidity
¼% Filter-Cel (1 expt.).......	—3.72	—2.01	—2.02	—4.27
½% Filter-Cel (3 expts.)......	—1.19	—4.00	—5.13	—7.20
1% Filter-Cel (3 expts.)......	+0.23	—5.78	—7.40	—8.62
Filter-Cel, average of all experiments	—0.99	—4.55	—5.51	—7.50
Additional change from Norit, average of all experiments	—0.30	+0.02	—8.68	—25.00
Total changes, Filter-Cel plus Norit, average of all expts.	—1.29	—4.53	—14.19	—32.50

There is evidently no increase in the glucose ratio, and therefore no inversion, from either Filter-Cel or Norit. In fact, we note a slight average decrease, which is probably also caused by adsorption. The ash is reduced considerably by the Filter-Cel, but not any further by Norit. This is no doubt due to the fact that the Norit used in these tests had not been treated with acid before use, and therefore still contained its original four per cent of soluble ash. It could thus not be expected to remove any appreciable quantity of ash, while acid washed Norit undoubtedly does reduce it. The largest reduction, by both Filter-Cel and Norit, is in the organic non-sugars, and here the Norit removes material which Filter-Cel does not act upon to any extent. To this latter class belong, as we have already seen, the free acids, and especially the coloring matter, which is not affected to any extent by the Filter-Cel treatment. The figures as a whole show very clearly that a preliminary treatment with Filter-Cel greatly facilitates the work of the Norit, because the Norit would have to remove impurities which are otherwise taken up by the Filter-Cel. That this is actually the case, was shown in our sugar house tests, which will now be taken up.

FACTORY TESTS WITH FILTER-CEL AND NORIT.

While the laboratory results just described seemed very encouraging from the standpoint of clarification, it was necessary to ascertain whether the process is feasible on the large scale, and how the final products, sugar and molasses, compare in quality and quantity with those made by the current sulfitation process. Unfortunately our supply of cane was very limited, owing to the disastrous climatic conditions during the past year. Only three runs could be made with the cane at our disposal. Further difficulties arose from the fact that we had only one filter press which could be used for the purpose in hand. In actual practice the mill juice would first be heated with Filter-Cel, sent through the presses, at once treated with Norit, and passed through another set of presses. With our equipment we either had to filter the Norit treated juice through the same press on top of the Filter-Cel precipitate, or else had to clean out the press every time after it had been used for either Filter-Cel or Norit filtration. The latter process was tried, as being theoretically preferable, but it was found that it took entirely too much time, and that the juice would surely deteriorate on being kept so long. So we continued the work by the former method. This procedure was better, but it still gave a lot of trouble, because the filtration through alternate layers of Filter-Cel and Norit was much slower than separate filtrations would have been. Under the circumstances it was useless to make analyses of the juices after each treatment, and we can give only the final figures after the use of both Filter-Cel and Norit.

In each of these runs about 8 to 10 tons of juice were used, and clarified in portions of about 3000 pounds each per clarifier. In the first two runs the raw juice was treated with ½% of Filter-Cel, heated until the blanket broke, then thoroughly mixed, and sent through the press. Filtration was very rapid, and after a little pumping back the juice came perfectly clear, though still dark. It was taken into a clarifier, mixed with 1% Norit, reheated and refiltered. This time the juice came out bright and almost water white. In the last two of the six clarifiers in run one, we had to omit the addition of fresh Norit, having run out of it temporarily. These clarifiers were only treated with Filter-Cel, and the juice sent through the press which had the Norit from the previous clarifiers in it. In the third run the Filter-Cel was omitted, and only 1% Norit used directly on the raw juice. The filtration was not as good here as where the juice had been pretreated, for obvious reasons, and the juice ran slightly milky for a while. After four clarifiers had been run in this way, the press began to leak badly, which is the worst thing that can happen with carbon filtration, because the success of the whole process depends on the complete elimination of the carbon, which otherwise goes into the sugar. So we decided to finish this run by using only lime on one clarifier, and sulfur and lime on the last two. This gave us some comparative data on the color of the products obtained by the chemical methods, as compared with Norit, or Filter-Cel plus Norit.

In run 1 the syrup was directly boiled to grain, and in runs two and three it was filtered through Norit, using 5% of this on the total solids in the syrup.

The regular analyses of the various products obtained are given in the following table, in which all the constituents are again calculated on the basis of 100 parts total solids, and also on 100 parts sucrose.

TABLE III

On basis of 100 parts total solids

	Sucrose	Glucose	Ash	Org. non-sugars	Acidity
Run 1					
Raw Juice..............	72.68	11.17	3.74	12.41	0.62
Clarified Juice..........	73.46	12.39	3.64	10.61	0.48
Syrup	75.07				
I. Molasses.............	53.45	33.33	7.15	6.07	
Run 2					
Raw Juice..............	69.87	17.18	4.67	8.28	0.86
Clarified Juice..........	69.92	18.87	4.20	7.01	0.59
Syrup	68.03	18.08	3.94	9.95	0.50
Syrup, treated with Norit	70.93	18.74	3.89	6.44	0.42
I. Molasses.............	52.69	38.27	7.69	1.35	
Run 3					
Raw Juice, Clar. 1-4....	78.39	10.82	3.83	6.96	0.66
Clarified Juice, do......	78.84	11.54	3.73	5.89	0.41
Syrup, Clar. 1-7........	80.15	11.68	3.20	4.97	0.74
Syrup, treated with Norit, do..................	81.59	11.38	3.24	3.79	0.20
I. Molasses.............	61.66	26.19	6.54	5.61	

On basis of 100 parts sucrose

	Total Impurities	Glucose	Ash	Org. non-sugars	Acidity
Run 1					
Raw Juice..............	39.25	16.09	5.27	17.89	0.87
Clarified Juice..........	37.63	17.57	5.06	15.00	0.68
Syrup	33.21				
I. Molasses.............	87.09	62.36	13.38	11.35	
Run 2					
Raw Juice..............	43.36	24.78	6.68	12.00	1.12
Clarified Juice..........	43.20	27.18	6.02	10.00	0.76
Syrup	46.99	26.58	5.80	14.61	0.74
Syrup, treated with Norit	40.99	26.42	5.49	9.08	0.59
I. Molasses.............	89.80	72.63	14.60	2.57	

TABLE III—Continued.

On basis of 100 parts sucrose

	Total Impurities	Glucose	Ash	Org. non-sugars	Acidity
Run 3					
Raw Juice, Clar. 1-4....	27.60	13.82	4.89	8.89	0.84
Clarified Juice, do......	26.85	14.63	4.73	7.49	0.52
Syrup, Clar. 1-7........	24.76	14.57	3.99	6.20	0.92
Syrup, treated with Norit, do....................	22.57	13.94	3.97	4.66	0.25
I. Molasses..............	62.18	42.48	10.61	9.09	

There was a slight increase in purity in each clarification, averaging 0.43 points, and a considerable purity increase in the Norit treatment of the syrup. The purity rises in the juices would have been larger, and probably would have approached those found in our laboratory experiments had it not been for an increase in the glucose ratios, due to slight inversion, which was caused by the fact, already explained, that we had to work with one single press. In the syrup treatment with Norit the glucose ratio dropped in both runs where it was used. There is noted in every case a slight decrease in the ash, and a considerable one in the organic non-sugars, including acidity, in clarification as well as in the syrup treatment. In this respect the factory tests corroborate our laboratory findings.

It is also noted that where Norit alone was used, in run 3, the ash dropped about 3%. In run 1 it was reduced about 4%, and in run 2 almost 10%.

These variations are probably partly due to varying quantities of insoluble ash introduced with the cane itself in the form of soil particles.

The reduction in organic non-sugars was 16.15% in run 1, 16.67% in run 2, and 15.75% in run 3. These figures are quite close together and agree fairly well with the 14% found in our laboratory tests. The Norit alone took up almost as much organic non-sugars as the Filter-Cel and Norit combined, and this proves that the work done by the Norit can be greatly reduced by a preliminary treatment with Filter-Cel, and that consequently the Norit will hold out longer, and will not have to be revivified as often as would otherwise be the case.

The removal of the non-sugars would be expected to promote crystallization upon concentration of the liquor, and we found this actually to be the case.

The treatment with Kieselguhr and carbon also sterilizes the juice quite effectively, as was found by Dr. Kopeloff, of this station.[24] His results, although based on only one run each in 1918 and 1919 and therefore not conclusive, seemed to indicate a slight superiority in this respect over clarification by sulfitation.

The most remarkable effect of the new process was noticed in the coloring matter of the various products, and in its important components, iron and polyphenols. These constituents were determined in the same way as last year,[20] and the results are presented in the following table which gives the color in the units used last year and the other constituents in parts per million in each product.

TABLE IV

	Total Color	Ferric Iron	Total Iron	Poly-phenols	Polyphenol iron compounds
Run 1					
Raw Juice	22	12	19	470	96
Clarified Juice	2	2.5	2.5+	50	20
Syrup	19	44	58	493	352
I. Molasses	84	132	167	2118	1056
I. Sugar	12	8	8+	40	46
Run 2					
Raw Juice	20	20	34	390	160
Clarified Juice	1	1	1+	55	8
Syrup	14	14	17	300	112
Syrup, treated with Norit	9	4	4+	175	32
I. Molasses	22	30	30+	653	240
I. Sugar	1	T.	T.	T.	T.
Run 3					
Raw Juice, Clar. 1-4	20	18	28	440	144
Clarified Juice, do	1	T.	T.	80	T.
Clarified Juice, Clar. 5, lime alone	26	50	77	410	400
Clarified Juice, Clar. 6-7, lime and sulfur	18	14	22	245	112
Syrup, Clar. 1-7	18	9	10	500	72
Syrup, treated with Norit, do.	8	2	2+	160	16
I. Molasses	27.5	T.	T.	488	32—
I. Sugar	T.	T.	T.	T.	T.

Upon comparing these figures with those obtained last year,[21] it is readily seen that, with the exception of the raw juices, the total coloring matter and its components are ever so much lower than last year. This proves the superiority of the new process in this respect over the older methods. The actual quantities are in many cases so small that they could be determined only approximately. We had to make use of the sign T., denoting "trace," and of the plus and minus signs for "somewhat more" and "somewhat less" than the figures which they follow. The raw juices this year had considerably more coloring matter, and particularly a much greater quantity of polyphenols than last year. But in spite of this the clarified juices, and consequently all the other products, had much less, even when compared with last year's products which had been treated with carbon in connection with chemical clarification.

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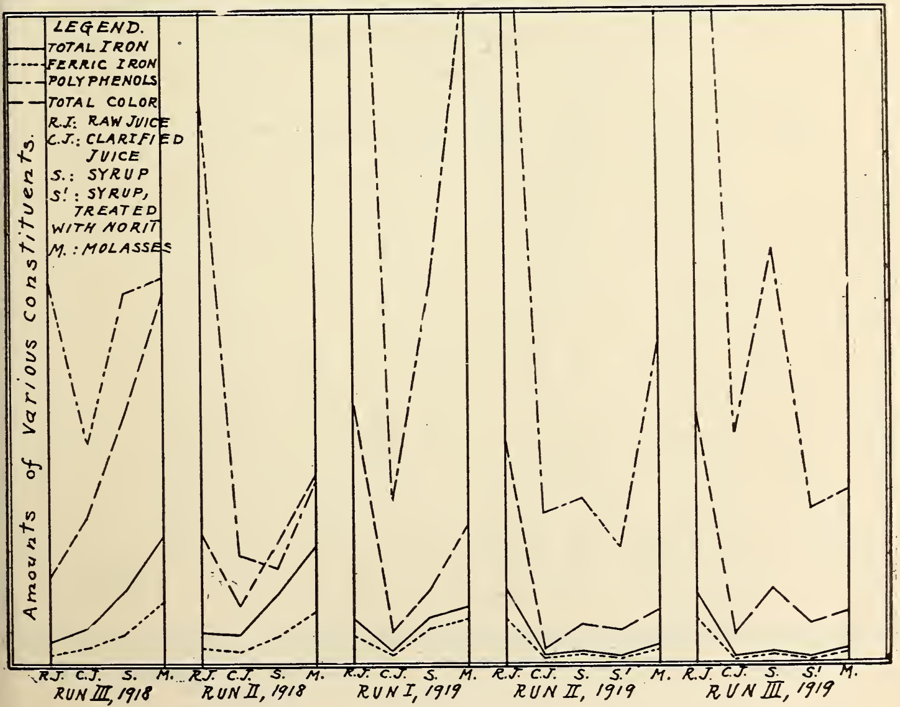
[24] La. Planter **64**, 14.
[20] La. Bull. 165, 14 ff.
[21] La. Bull. 165, 19.

This year's raw sugars, unwashed, were of a light yellow color, without any grayish, greenish, or reddish tint, and would on this basis be classified as "yellow clarifieds," corresponding to about No. 19 Dutch Standard.

FIGURE 1



For the sake of better comparison we have again calculated all the figures given in Table IV on the basis of equal quantities of total solids, and the results are shown graphically in Fig. 1, which is drawn on the same scale as last year's.[22] In order to further facilitate comparison we have also inserted the graphs for run 3 of last year, where the straight sulfitation process was used, and for run 2, where carbon was employed in addition to it. It will not be necessary to go into details again, and we shall only point out some salient features. In run 3 of 1918 the color, ferric iron, and total iron increased quickly from raw juice through to the molasses. In run 2, 1918, the same constituents, and particularly the total color, decreased from raw juice to clarified juice, but increased rapidly again in the syrup and molasses. In run 1, 1919, the changes were similar to those in run 2, 1918.

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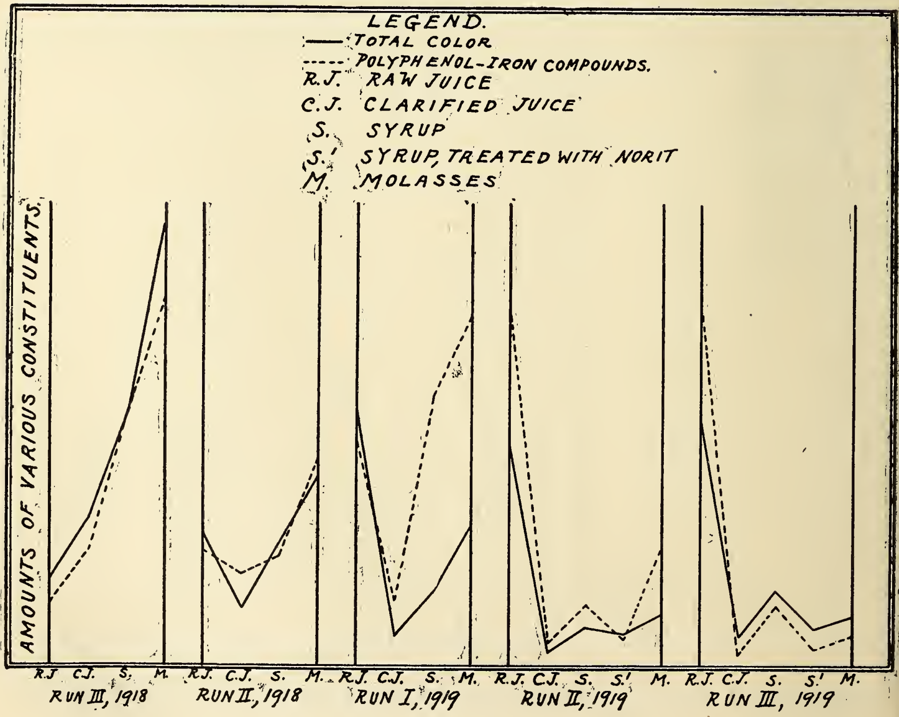
[22] La. Bull. 165, 21.

FIGURE 2.



This is largely due to the well known fact that in the first run of a campaign the products pick up a lot of foreign matter, especially from pipes and machinery, and the iron therefore increases rapidly. In run 2, 1919, however, the rise from clarified juice to syrup, and again from carbon treated syrup to molasses is very slight. The Norit treatment of the syrup naturally caused a drop in all of the figures. In run 3, 1919, the increases from clarified juice to syrup are again larger, because here the last three clarifiers were not treated with carbon at all; from Norit treated syrup to molasses the figures rose but slightly. The large drop in total color and in polyphenols, from raw juice to clarified juice, shows very clearly in the graphs.

The close relations between total color and polyphenol-iron compounds is again strikingly demonstrated in Fig. 2, which corresponds to Fig. 2 published last year.[23] The graphs for runs 3 and 2 of 1918 are again included. It is seen that there is indeed an important connection between the two factors named, just as we concluded from last year's work. However, there is a slight irregularity in run 1 of 1919, in that the total color is considerably less than we would expect from the polyphenol-iron compounds present.

It need hardly be emphasized that the coloring matters are actually removed in this process, while in the sulfitation process they are only bleached temporarily, as explained before.

One of the most remarkable observations made this year is that in all the syrups, and even in the molasses and sugars, there is less iron than can combine with the polyphenols still present, whereas last year we found an excess of iron in some of the syrups, and in all the molasses and sugars. For this reason the addition of ferric salts to this year's final products caused a darkening in the color. The low figures for iron are easily explained, as the corroding effect of the sulfites in an acid medium which is so pronounced in the sulfitation process, is excluded in the new method.

The sugar manufacturer is naturally most interested in the yield and quality of the sugars and molasses obtained by any particular process, and we shall therefore discuss this phase of the problem a little more fully. As we did not have enough cane to run some complete comparative tests with the sulfitation process, it will be best to compare the averages of this year's results with those of last year. The sucrose content of the raw sugars was the same as last year, 93.5. The better quality of the sugars was therefore largely in the color, but this in itself is a great advantage, as every sugar man knows, because the molasses, as we have seen, are also so light colored that a considerable quantity could be boiled back for white sugar. The total non-sugars average 1.65% this year, against 2.69% last year, having been effectually removed by the carbon, but the glucose averaged higher than last year, 3.81 against 2.03, owing to the higher glucose content of all the initial products.

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[23] La. Bull. 165, 26.

In 1918 the average purity of the five syrups was 79.47, and we recovered in the first sugar 59.92% of the sucrose contained in the syrup. In 1919 the three syrups averaged 77.24 in purity, and we recovered 62.78% of its sucrose content in the first sugar. Although the small amount of work does not permit us to draw definite conclusions, it is nevertheless quite certain that the new process furnishes sugar of infinitely better color and with a smaller quantity of non-sugars, particularly organic non-sugars; and there are good indications that the yield will be at least equal, if not superior. This inference is further strengthened by the observation that the massecuites boiled much more freely and purged better than similar ones made by the sulfitation process.

It is very gratifying to note that at least some of the sugar planters in this state have at last started some factory experiments along the same lines as done at the station. The actual data obtained so far are still very meagre, but since they seem to bear out our own conclusions, as far as the feasibility of the process is concerned, we shall shortly mention the reports we have received from two of those factories.

At the first of these places a three days' run was made with Kieselguhr alone. The average increase in purity was 0.28 points. The superintendent of this factory makes the following statement: "The filtration of the juices was very easy, the boiling in the vacuum pan was a surprise to the sugar boiler, and the product was in no way inferior to sugar made by the sulfur and lime process."

At the other factory a 24-hour run was made, grinding 700 tons of cane. An average of 17.2 pounds of Filter-Cel per ton of cane was employed on the raw juice, beginning with 30 pounds, and gradually decreasing the quantity to 12 pounds. No lime or sulfur were used. In the first four periods the average purity rose from 73.6 to 75.8, the acidity dropped from 1 to 0.75 cc., and the glucose ratio from 21.2 to 20.2. In the last four periods the purity increased from 74.5 to 75.8, the acidity fell from 1 to 0.9 cc., and the glucose ratio only changed from 21.4 to 21.7. These results confirm our own findings. Filtration was very rapid, and the press cake could be washed to a sucrose content of 0.25%, which would mean a saving of 1 pound of sugar per ton of cane. Other advantages may be expected from the fact that the juices reach the effects more quickly, that the corrosive effect of the sulfurous acid is eliminated, and that the scale would be reduced.

The manager of this factory sent us a report with a letter in which he says, in part, as follows: "Later in the season we repeated this experiment, grinding something over 2000 tons of cane using Kieselguhr in the same manner as described in this report and then treating the syrup with Norit. Norit removed a large percentage of the coloring matter and gave us the liquor from which we abstracted first a strike of granulated sugar, and then, making grain on syrup in one of our pans, we were able to take the run-offs from the granulated sugar strike and make a strike of yellow clarified sugar. The molasses from this yellow clarified sugar was then treated with Norit, and sold as commercial molasses at 65c per gallon. In passing this molasses over Norit, we made a positive rise in purity of, at least, four points, to 40. There was no lime or sulfur used in the making of this molasses."

The fact that this molasses sold at such a good price, is noteworthy. Our own molasses were greatly superior in color to anything we have ever seen in the way of unbleached goods, and at least equal to the general run of bleached ones, which, as is well known, do not keep their color on exposure to the air. The taste is naturally different from that of molasses made by chemical processes, especially by those where sulfur is used. The well known sulfur taste is of course entirely absent, and in other respects the flavor is modified. This would be expected, because among the non-sugars removed there are certainly some which affect the flavor. This is readily seen by the practically complete absence of any odor from the clarified juice, while that made with lime and sulfur has a rank, disagreeable odor.

In brief, the results obtained so far with the new process are very encouraging, and it commends itself for thorough trials carried out for a sufficient length of time to gather complete information on its merits in actual factory practice, and to collect reliable cost data.

SUMMARY.

Previous investigators have found that nearly three-fourths of the impurities which are removed by treatment of cane juice with heat and lime, can be taken out by filtration in the cold, and that therefore the chemical effect of the lime treatment plays only a small part in clarification with this process. It was also shown by the same investigators that the greater part of these impurities exist in the juice in colloidal form. Conclusions based on these facts are further developed in this paper, and it is pointed out that the effectiveness of the various chemical clarification methods at present in use may in their broad outlines be explained by colloid-chemical considerations. It is very probable that surface energy, and particularly adsorption, is the principal factor in these clarification processes. It follows from these theoretical considerations that cane juice clarification may be brought about without the use of any chemicals whatever, but simply by the use of efficient adsorbents. Laboratory and factory tests have given strong evidence that this is actually the case, and it was found that, in comparison with the sulfitation process, at least the same quantity of first sugar of greatly superior quality can be made by clarification with ½% Filter-Cel, followed by treatment with 1% Norit, and filtering the juice in both cases, which is easily and rapidly done. The first molasses is so very light in color that the recovery of high grade sugar can probably be materially increased, still leaving a molasses of higher market value than that made by the usual plantation methods.

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TOMATO WILT

BY

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TOMATO WILT.

C. W. Edgerton and C. C. Moreland.

The disease of tomatoes, known as the tomato wilt, sleepy disease, fungus wilt and Fusarium wilt, is one which has come much into prominence during the past few years. It is scattered all over the world, more abundant in the warmer regions, but present to some extent in cooler countries. In the United States, it is well distributed over the Southern states and extends as far north as Illinois, Indiana, Ohio, and New Jersey. It is only occasionally found in the northern tier of states.

In the South and Middle states, the disease causes a very heavy loss in many of the tomato growing sections. In Louisiana, twenty-five per cent would be a conservative estimate of the loss caused by the disease. In some regions of the state, the loss is much greater than this, in some places it being very difficult to grow any of the ordinary varieties of tomatoes. This disease also causes heavy losses in the tomato sections in the Ohio Valley and in Maryland and adjoining states.

In Louisiana, the disease is most abundant on the bluff, prairie, and sandy soils. It occurs only to a small extent in the heavy alluvial soils.

PREVIOUS WORK ON THE DISEASE.

Although the tomato wilt has been known for a considerable period, the literature upon it is rather scattering. Other than brief notes on its occurrence in various countries, but little has been written concerning it until recent years. Practically all of the investigations on the disease have been carried on within the past ten years. The possibility of obtaining wilt-resistant strains of tomatoes was the phase of the problem which first received consideration. This line of work was started by Norton (8, 9) and Essary (6) and since, has been taken up by Edgerton and Moreland (2, 5), Humbert (7), Pritchard, Durst, and others.

Another phase of the problem has also been considered in the morphological and physiological studies of species in the genus Fusarium, which have been made by Wollenweber (12), Sherbakoff (10), and others.

Other than on these lines of work, little has been written on the tomato wilt, but of recent years investigators have been considering the disease from different angles. These recent investigations will be considered later in this publication.

NATURE OF THE LOUISIANA INVESTIGATIONS.

In Louisiana, the study of the tomato wilt has been in progress since 1909. The disease has been considered mostly from a pathological standpoint. The causative fungus has received but little attention, except in its relation to the disease. A morphological and cultural study of this fungus and related species in the same genus has been made by several investigators in the past few years, and it did not seem worth while to touch this phase of the subject.

The work on the disease was commenced as an attempt to obtain wilt-resistant varieties, for use in those districts that were having trouble in growing tomatoes, but later the problem was enlarged to include a general study of the disease.

METHOD OF WORK.

The work on the tomato wilt in Louisiana has been carried on in the field, laboratory and greenhouse. For the field work, a piece of ground has been available on which tomatoes have been grown every year since the work started, thus making the soil as badly infected with the disease as is possible to have it. In this ground has been conducted the selection work and the tests of resistant and tolerant varieties.

The greenhouse has been used extensively for testing varietal resistance, for selecting resistant strains and in the study of the effect of such factors as temperature, soils, etc. By the use of a new method of growing and inoculating the plants, the greenhouse work has become more efficient and has given some valuable results. This method has been described fully in a previous publication. (5) and it is only necessary to briefly describe it here.

In this method, the soil in which the young tomato plants are to be grown, is placed in pots, covered with paper and sterilized in the autoclave. The upper layer of the soil is then heavily inoculated with a pure culture of the wilt-producing organism.

It has been the custom to grow the fungus on sterilized bean pods and then work the pods into the soil. Immediately after placing the cultures in the soil, the seed is planted. In such a treated soil, the young tomato plants take the disease very quickly (Fig.1).

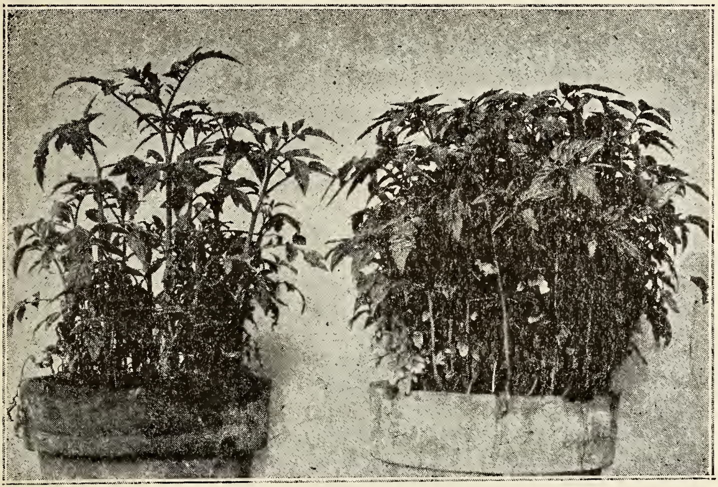

FIG. 1. Tomato wilt in young plants in reinoculated sterilized soil. The soil in the pot on the left was sterilized and reinoculated with pure cultures of *Fusarium lycopersici* just before planting, while the soil in the pot on the right was sterilized but not inoculated. A large percentage of the plants in the first pot are dead.

ADVANTAGE OF STERILIZED SOIL.

The advantage of a sterilized over an unsterilized soil in the greenhouse work is very marked. The sterilization by steam eliminates a large number of the bacteria and other organisms in the soil which normally tend to check the development of the tomato wilt fungus. When this soil is inoculated with *Fusarium lycopersici,* the fungus grows very rapidly and a much heavier infection is obtained in young tomato plants than in plants growing in unsterilized infested soil (Fig. 2). Many experiments have been run during the past several years that show a greater infection with wilt in young plants growing in reinoculated sterilized soil than in ordinary inoculated soil. The result of two of these experiments are given in Table 1.

TABLE I.

Effect of sterilized and unsterilized soil on the development of tomato wilt in the seed bed.

Treatment of Soil	I		II	
	No. Plants	% Diseased	No. Plants	% Diseased
Unsterilized	213	60.6	344	22.7
Sterilized	367	85.6	281	86.8

Not only does the sterilized soil allow a greater infection but the young tomato plants develop the disease earlier and seem to die faster. Under favorable temperature conditions, the young plants will begin to die in less than two weeks after the seed is planted and in less than ten days after the plants come through the ground.

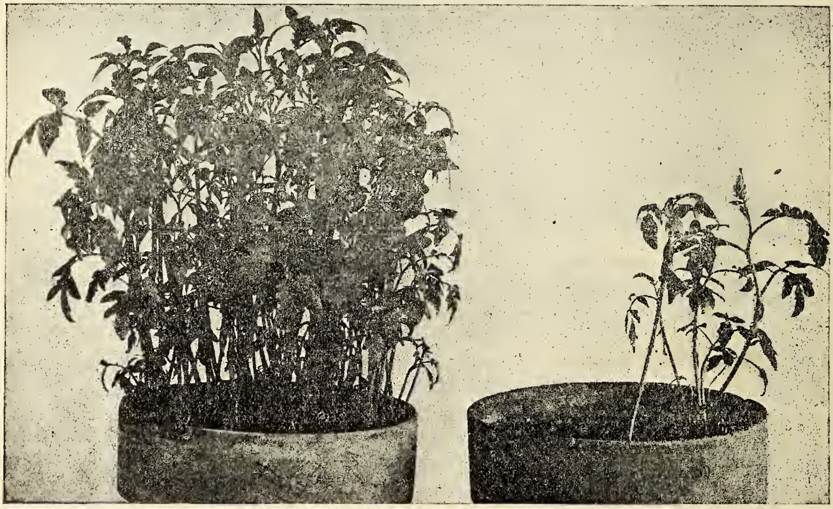

FIG. 2. Effect of sterilization of soil previous to inoculation on the development of the wilt. The soil in the pot on the right was sterilized and then reinoculated with pure cultures of *Fusarium lycopersici*; the soil in the pot on the left was inoculated but not sterilized. Most of the plants in the sterilized soil died with the wilt.

That a disease will develop much more readily in a sterilized soil than in one that has not been sterilized is a well recognized fact at present. Many diseases, not only those produced by soil-inhabiting fungi, but also those which occur on seed, develop much better on young plants that are growing in sterilized soil. Observations which have been made on a few other diseases in Louisiana during the past few years are of interest at this point and show the importance of this method of study. Seed of cotton and beans infected with the anthracnose diseases, when planted in sterilized soil, produce plants which are severely affected and usually die while in the seeding stage as a result of the disease.

The eggplant blight fungus, *Phomopsis vexans,* causes a much larger percentage of the young plants to damp off in sterilized soil than in unsterilized soil. The common Rhizoctonia grows much more readily and does much more damage in sterilized than in unsterilized soils. It is very difficult to check an outbreak of damping off caused by Rhizoctonia in sterilized soil. In the work in Louisiana with truck crop diseases, the sterilization of soils is not usually recommended as a preventative for Rhizoctonia, because of the fact that if the sterilization is not complete enough to kill all of the Rhizoctonia or if the soil becomes reinfected, the disease is much more severe than if the soil had not been sterilized. A similar condition sometimes occurs in beds in greenhouses that have been allowed to dry out all during the summer months. In such soil many of the common soil organisms are killed by the heat and dessication, and the Rhizoctonia, which is not killed, has a much better chance for development when the soil is again planted. Such soil, if spaded up and moistened about six weeks before planting and kept in a good condition of tilth, will have less of the damping off than if it is prepared just before planting.

ADVANTAGE OF POTS OVER FLATS OR LARGE BEDS.

In carrying on the experiments with tomato wilt in the greenhouse, it was found that pots were much more satisfactory for growing the plants than boxes, flats or benches. In the latter, the development of the wilt was not equal in the different sections. Generally in a flat, the plants around the edge would show a much higher infection than in the middle. This same condition has been noted by Humbert (7), who states that it is probably due to the higher temperature of the soil around the edge of the flat. While the temperature of the soil is a factor, it is probable that better aeration of the soil is also important. By using a number of pots, much better results can be obtained than with the flats or benches. With the former it is much easier to obtain a similar moisture content and temperature.

APPEARANCE OF DISEASED PLANTS.

Although the wilt disease may occur on tomato plants in any stage of their development, in the field it usually becomes most noticeable at about the time the plants are developing their first fruits. The disease first shows on the lower leaves. These gradually turn yellow and finally die. The diseased plants also usually assume a stunted appearance, due to a shortening of the internodes between the branches. As the disease progresses, more of the leaves turn yellow and dry up and finally the whole plant may die. A susceptible plant generally dies rather rapidly, but one of a tolerant or resistant variety may live throughout the season with the disease present in the roots and stems. The time intervening between the first symptom of the disease on the lower leaves and the final death of the plant varies considerably, depending upon weather conditions, varietal susceptibility and possibly other factors.

The amount of infection in fields varies considerably. Where a proper system of rotation is followed, and the young plants are grown in seed beds free of the disease, the affected plants are generally scattering throughout the fields. Where no rotation is followed, or the plants are set from infested seed beds, frequently nearly all of the plants become diseased and die. Such a field is shown in figure 7.

Under ordinary field conditions, some fruits usually set on diseased plants but not as many as on healthy ones. The development of these fruits depends upon the severity of the infection. Usually on ordinary susceptible varieties, they do not grow very large and generally ripen prematurely. As the disease causes a reduction in the root system and foliage, the development of the fruit is materially hindered. The fruits generally color up on these diseased or dying plants, but they are not normal in size or flavor. With resistant or tolerant varieties, however, the fruit seems to develop fairly well, even though the disease is present.

The yield from diseased plants of a susceptible variety, depends to a great extent upon the time of infection. A plant that becomes infected rather late, often ripens a few fairly good fruits, but a plant that becomes infected early usually dies before any first grade fruit can develop and ripen. This is the reason why some of the early maturing varieties, such as Earliana and June Pink, often make a crop in badly infested soil. If large healthy plants of these varieties are set in an infested field, the development of the fruit is so rapid that the wilt does not have time to kill the plants before the first fruits are mature. With a later maturing variety, the wilt has a longer period to develop and consequently decreases the crop to a greater extent. If the early maturing varieties are grown in infested soil in the seed bed, and consequently are diseased at the time of setting in the field, they generally die before a satisfactory crop is made.

The wilt disease affects the roots as well as other parts of the tomato plant. The roots, especially the smaller ones, turn black and rot. During the later stages of the disease often a considerable percentage of the roots are dead or are so badly diseased that they cannot function.

There is no external development of the wilt fungus until the very last stage of the disease or until the plants are dead. Sometimes when the plants are nearly dead, black lesions, in which the fungus develops, will form on the stems. After the plants are dead, the whole stem becomes black and the fungus fruits abundantly on the surface. During wet weather, the fungus shows a pinkish cobwebby growth of mycelium.

THE DISEASE IN YOUNG PLANTS.

The wilt disease may develop in very young plants. If seed is planted in infested soil and the temperature conditions are right, the young plants may show the disease in less than ten days after coming through the ground. The plants that show the infection this young, usually die very quickly. Plants that do now show the infection until they are three or four weeks old, usually succumb much more slowly. The leaves turn yellow and wilt during the sunny part of the day and the plants finally die. If the plants are crowded and tender, frequently the tissues of the stems become soft and watersoaked, but usually the disease acts very similar to the way it does in larger plants.

If the temperature conditions are not satisfactory for a good development of the disease, many young plants in the seed bed will become infected without showing the disease and will be set in the field. Such plants generally die before they can bloom and set fruit.

INTERNAL APPEARANCE OF DISEASED PLANTS.

The internal appearance of a tomato plant affected with the wilt disease is very characteristic. In fact, a diagnosis of this disease is best made by cutting the stem of a suspected plant and observing the coloration of the various tissues. The fibrovascular tissues of the roots and stems are turned brownish to blackish in color. The whole inside of the root of a diseased plant is turned black, while the stem has a discolored ring just underneath the cortex, (Fig. 3). The pith of the stem is not normally discolored. Occasionally, in plants that are nearly dead, or that show a secondary infection with bacteria or fungi, the

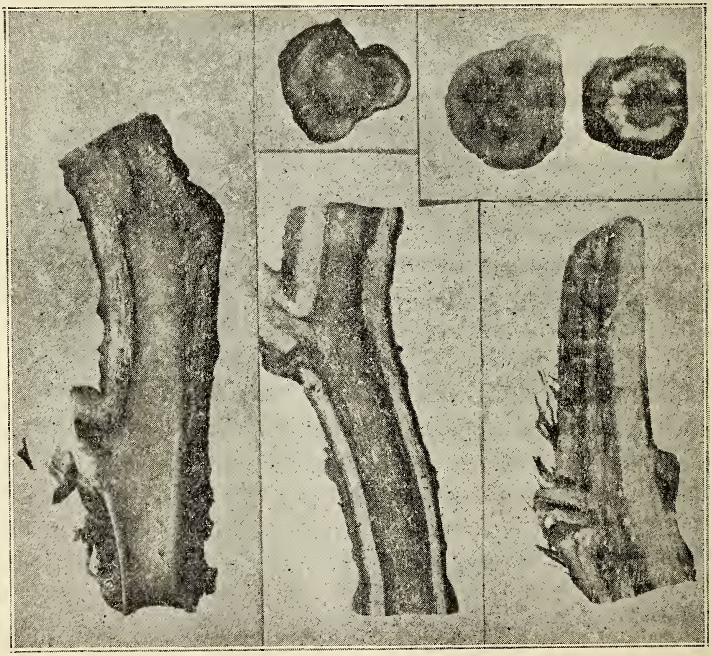

FIG. 3. Discoloration of inside of tomato stems caused by the tomato wilt disease.

pith cells will be dead and somewhat discolored; but such a condition is not a normal development of the wilt disease. The leaves which are turning yellow also show the discolored fibrovascular bundles in the petioles and veins. This discoloration is continuous from the blackened tissues in the stems, through the leaf traces and into the leaves. Occasionally also the black fibrovascular bundles pass into the young developing fruits, (Fig. 4).

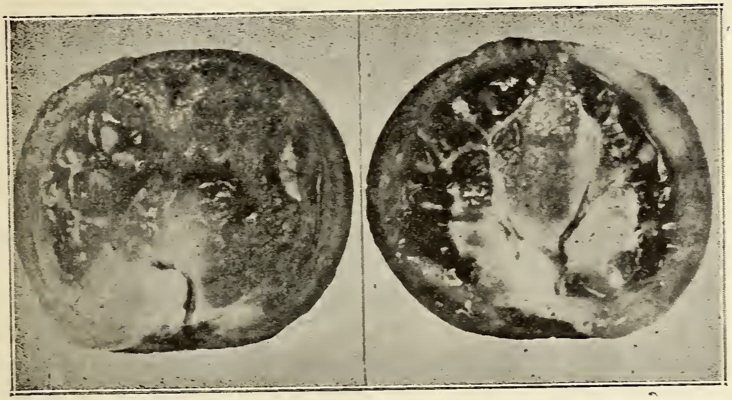

FIG. 4. Discoloration of fibrovascular bundles inside of a tomato infected with the wilt.

With slightly infected plants, the discoloration may not pass into the leaves, only showing in the roots and stems. Occasionally the discoloration may develop in only one side of a stem, and when this occurs the leaves die on one side of the plant, while those on the other side of the plant remain healthy, for a considerably longer period.

In the young plants in the seed bed, the discoloration shows the same as in the large plants. In a cross section of a diseased stem, the little fibrovascular bundles show as black dots. These discolored bundles can usually be seen without cutting the stem, by merely holding the plant up to the light.

COMPARISON WITH OTHER DISEASES.

There are several other diseases of tomatoes which are frequently confused with the tomato wilt by growers and gardeners. These are the bacterial blight, early blight, Sclerotium wilt and Mosaic disease. The bacterial blight occurs sporadically in Louisiana, sometimes it is abundant, while at other times, it is difficult to find. It apparently seems to be most abundant in wet seasons. This disease is quite frequently confused with the tomato wilt. However, with the bacterial blight, there is not the slow yellowing of the lower leaves and the gradual death of the plants, but instead the leaves wilt rapidly and the whole plant dies quickly. The inside of the stem is also turned black but the blackening is more complete than with the wilt. With the wilt, only the fibrovascular region is discolored, the pith remaining white, but with the bacterial blight, both the fibrovascular region and the pith are blackened.. There are times when a microscopic examination is necessary to determine these diseases absolutely, but this is not ordinarily necessary, except in cases where both diseases may be present in the same plant. The microscopic examination shows the causative organisms, bacteria in plants affected with the bacterial blight and the fungus mycelium in plants affected with the wilt.

The early blight is a leaf disease which often becomes severe enough to defoliate the plants. As the disease develops first on the lower leaves, these frequently become yellow. The disease, however, develops definite black spots on the leaves, which makes its diagnosis easy. The interior of the stem is not blackened.

The Sclerotium wilt is a disease of the stem of the plant, near the surface of the ground. The whole cortex of the stem and the cambium layer is rotted off. The plants sometimes wilt rather quickly. The interior of the stem is not discolored. There is usually a rather heavy development of mycelium in the affected area on the stem, and, if weather conditions are right, there is a development of small sclerotia about the size of mustard seed in this decayed tissue.

The Mosaic disease is characterized by light colored and often finely divided leaves. The plants do not often die but they do not have a vigorous, healthy appearance. There is no discoloration in the stems.

CAUSE OF THE DISEASE.

The tomato wilt disease is caused by a fungus which passes under the name of *Fusarium lycopersici*. This name was first given by Saccardo to a fungus which he found on a decaying tomato fruit. The fungus which causes tomato wilt is not usually found on decaying fruit, though Wollenweber (12) reports successful inoculations on the fruit. The name, *Fusarium lycopersici*, is now universally used for the tomato wilt organism, and it would be unfortunate if it were found that the fungus with which Saccardo was working was different.

This fungus belongs to the sub-group, elegans, of the genus, Fusarium. This group contains a number of forms very similar, morphologically. This is the group that contains all of the Fusarium wilt organisms, including the ones causing wilt diseases of cotton, cowpea, melon and cabbage. It is not easy to separate these forms by morphological or cultural characters, though the studies of Wollenweber, Sherbakoff, and others have shown slight differences.

Fusarium lycopersici produces two types of conidia, the small, single celled, hyaline microspores and the larger falcate, hyaline, septate macrospores. In the macrospores, there are usually three septae, though any number from one to five are not uncommon.

The fungus grows well on almost all of the common culture media, producing spores in abundance in pure culture. There is some variation in different strains of the fungus on culture media. Some cultures make an almost strict growth, while others are covered with a rather heavy floccose growth of aerial mycelium. On some culture media, some strains produce a rather deep pink or purple color while other strains are colored only slightly. These varying strains are all able to infect young tomato plants, producing the typical wilt disease.

Fusarium lycopersici grows best on a medium testing not higher than +15 of Fuller's scale. It will grow on a medium testing slightly above +30 but the growth is considerably retarded even at +20. Growth does not seem to be retarded in a medium testing slightly alkaline.

THE FUNGUS IN THE PLANT.

Fusarium lycopersici gains entrance to the tomato plant through the roots. The fungus enters the fibrovascular strands and then grows up the plant following the ducts in the bundles. As the fungus progresses upward, the bundles turn to a brownish or black color. A section (Fig. 5) of a diseased stem shows the fungus hyphae to be abundant in the ducts. A duct may be crowded with the hyphae or the number of threads may be limited. These threads do not usually run straight through the ducts, as it is more usual for them to twist around in various ways.

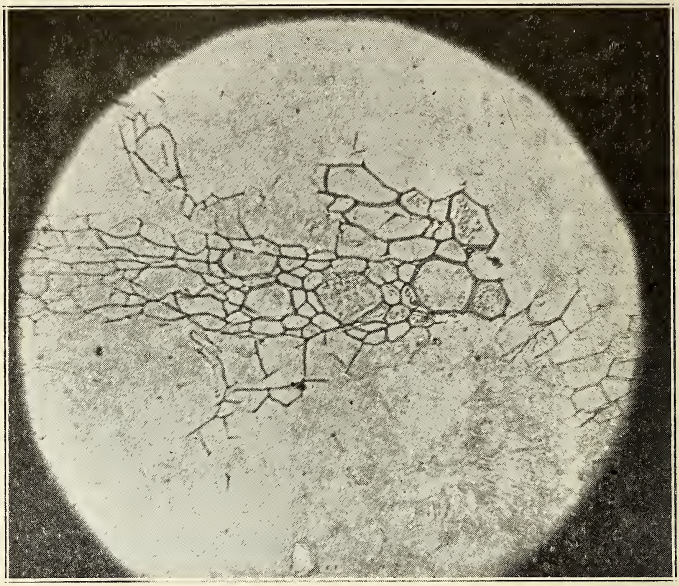

FIG. 5. Photomicrograph showing mycelial threads in the fibrovascular bundles of an infected tomato stem.

There is usually, if not always, a production of gum around the infected bundles. This gum is deposited in the cells, possibly as an attempt by the plant to isolate the diseased portion. This zone around the fibrovascular bundles is shown in the photomicrograph in figure 6.

After the disease becomes severe, the fungus may break out to the surface, though this seldom occurs until the plant is practically dead.

METHOD OF INFECTION.

No direct attempt has been made to determine the exact method of infection, but it is probable that the infection may take place at any place on the small roots. In seed bed plants, the discolored bundles can be readily traced down to a small dead root or a discolored area on a root. Tisdale (11) has investigated the method of infection with the fungus causing the flax wilt, a fungus very similar to *Fusarium lycopersici.* He found that the fungus may gain entrance through the root hairs, through the cortical layer or through stomates. It seems probable that *Fusarium lycopersici* can gain entrance to the tomato root in as easy a manner. The hundreds of observations that have been made on small plants in the seed bed would seem to show that the fungus can gain entrance to the young root at any point.

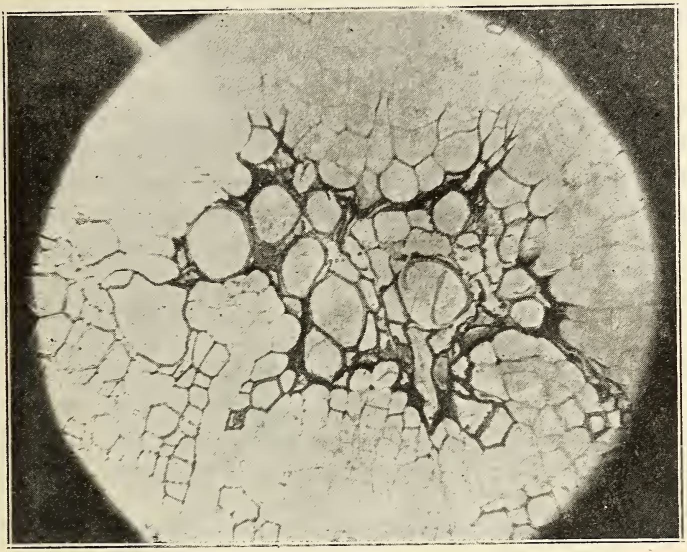

FIG. 6. Photomicrograph of an infected tomato stem showing gum formation around fibrovascular bundle.

LIFE OF SPORES ON THE SEED.

Although the wilt disease is not ordinarily carried from season to season, and from field to field on the seed, it seems probable that this may sometimes occur. It is often difficult to explain the introduction of the disease in new territory in any other manner than by the seed. While the disease is carried to new territory more frequently by diseased plants, it does find its way into localities where no plants have been brought in from outside.

As the production of spores on dead plants is very profuse, some of them may very easily find their way to the surface of ripening fruits. In the seed saving process, it is possible for some of these to become attached to the seed and remain there until the seed are planted.

In order to determine whether spores placed on the seed would remain viable and produce infection on young plants, a small amount of seed was immersed in a suspension of spores of *Fusarium lycopersici* on October 12, 1915. This is earlier in the season than seed would ordinarily be saved from the fall crop of tomatoes, though considerably later than the spring crop. This seed was dried and kept until January 22, 1916, when it was planted in sterilized soil in the greenhouse. This is about the time that seed is usually planted in Louisiana for the early crop of tomatoes. The plants growing from this seed became very badly affected with the wilt disease while plants from untreated seed planted at the same time remained healthy. This shows that spores will live for sometime on the seed and will produce the wilt disease on the young plants that grow from the seed.

LIFE OF FUNGUS IN THE SOIL.

There are no direct and reliable data regarding the length of time that *Fusarium lycopersici* will live in soil in which tomatoes are not being grown. There is no doubt but that it will live for a period of three years or more, yet a three years' rotation will eliminate the disease to such an extent that the actual loss in a field is small.

With some of the wilt diseases of other plants such as cotton and cabbage, there are data to show that the pathogenes will live in the soil, without the host plant, for from seven to fifteen years. It is difficult to obtain reliable data on such a question as this, as it is seldom that all of the necessary information can be obtained.

Because a field develops tomato wilt after being in another crop for a number of years, does not mean that the fungus remained alive in the soil during all of that period. There are so many ways that the fungus might be brought in that it is usually impossible to determine whether the original infection has remained in the field. The fungus may be brought in by the wash from other fields or by the wind blowing the spores from other places. Furthermore, the fungus may unknowingly be brought into the field on the young tomato plants that are transplanted. Many cases have come to notice in which infection in new ground, or in ground that had grown other crops for years, was traced to the infected seed beds from which the plants were taken.

SOIL PREFERENCE.

The tomato wilt has a natural preference for some soils. It seems to develop best on the lighter, well drained fertile soils and does not develop well on the heavy alluvial soils. In Louisiana, the disease is found most abundant on the bluff or loess soils, on the prairie soils in the southwest part of the state, and in some of the sandy soils in the north and west part of the state and the Florida Parishes. In the alluvial Parishes along the lower Mississippi river, it is not abundant enough to be important. Occasionally diseased plants may be found in that region but they are very scattering. For some reason or other the disease has not as yet become serious around Norwood, which is in the principal tomato growing section of the state. However, the disease is spreading each year in that section and it may become important there in the future, as the soil would seem to be favorable for the development of the disease.

In the greenhouse experiments, it has been found that the soil that gives the best development of wilt, is a mixture of common garden soil and leaf mold, usually from one-half to one-third of the latter. The presence of sand in the soil does not seem to increase the wilt. In fact, in experiments in which a high percentage of sand was used, the wilt did not seem to develop as well as in soil without the sand.

The different soils in the state have not been tested in the greenhouse to any extent. Some experiments were started but it was found that no dependence could be placed upon the results. As the development of the wilt depends to a large extent upon the amount of humus or nitrogenous matter in the soil, and as the amount of this varies greatly in different lots of the same soil, a very great variation in results was obtained.

EFFECT OF SUBSTANCES IN SOIL ON WILT.

The effect of chemicals and other substances added to the soil on the development of the tomato wilt is a question that has received but little consideration in the past. This kind of work is difficult and unsatisfactory when carried on in the field but when carried on in pots in the greenhouse, reliable results can be obtained in a short space of time.

A couple of experiments were carried on in the greenhouse at Baton Rouge during the years 1915 and 1916. The first experiment was started in September 1915. Thirty-three six inch pots were filled with garden soil and compost, and sterilized in the autoclave. These were treated in eleven different ways, making three pots with each treatment. Substances in varying amounts were added to these pots and worked into the soil. The substances used were lime, oak wood ashes, kainit, sulfur, sulfuric acid, formaldehyde (40% solution), corrosive sublimate and copper sulfate. The lime, ashes, kainit and sulfur were added to the soil in a dry form, but the other substances were dissolved in water so that 400 cc. of the solution was added to each pot. All of the pots were heavily inoculated with four different pure cultures of the tomato wilt fungus, this inoculation following the lime, ashes, kainit and sulfur treatments by one day and preceding the other treatments by one day. The pots were all planted with Acme tomato seed on September 29, one day following the application of the solutions. The experiment

TABLE II.

Effect of Substance in Soil on Development of Tomato Wilt.

Substance added	Amount per pot in grams	Rate per acre in lbs. (approx.)	Number of Plants	Percent Diseased
Check........................			87	74.7
Lime........................	8.0	4000	109	88.1
Lime........................	20.0	10000	141	31.2
Wood Ashes.....................	20.0	10000	113	41.6
{ Lime...................... { Wood Ashes.................	14.2 20.0	7100 10000	98	56.1
Kainit........................	1.0	500	78	75.6
Sulfur........................	1.0	500	102	56.8
Sulfuric Acid..................	1.3	670	92	67.4
Formaldehyde (40% solution)....	3.9	2010	84	53.6
Corrosive Sublimate............	0.65	335	17	0.0
Copper Sulfate.................	1.95	1005	109	72.5

continued until November 22, when the final percentage of wilt was obtained. The various treatments, the number of plants in the three pots of each treatment and the final percentage of wilt are given in Table II.

An examination of the table shows that corrosive sublimate was the only substance that completely eliminated the wilt, but this substance was added so strong that germination was almost prevented, only seventeen plants coming up in the three pots. Of the other substances, the heavy application of lime seemed to be the most efficient in checking the disease.

Following the above experiment, another one was started on December 5, 1915. In order to test out more fully the lime and corrosive sublimate, these substances were used in different amounts. The formaldehyde was used in the same amount that is usually recommended for soil sterlization—that is, a solution made of one pint of formaldehyde and twelve and one half gallons of water with one gallon added to each square foot of soil. This experiment was run in the same way as the preceding one. The temperature in the greenhouse at the time the experiment was run was not high enough for the best results, but this factor was not fully appreciated at the time. Livingston Globe was the variety of tomato used. The results obtained in the test are given in Table III.

TABLE III.

Effect of Substance in Soil on Development of Tomato Wilt.

Substance added	Amount per pot in grams	Rate per acre in lbs. (approx.)	Number of Plants	Percent Diseased
Check			155	51.0
Formaldehyde	11.0	See text	153	0.0
Corrosive sublimate	0.5	250	112	1.8
Corrosive sublimate	0.3	150	154	1.9
Corrosive sublimate	0.1	50	138	10.9
Lime	40.0	20000	184	4.4
Lime	20.0	10000	180	21.7
Lime	8.0	4000	117	17.1
Wood Ashes	20.0	10000	57	5.3

The table shows that all of the substances that were added to the soil decreased the wilt to some extent, but the two heaviest applications of corrosive sublimate, the heaviest application of lime and the formaldehyde were the most effective. The strength of formaldehyde used was strong enough to sterilize the soil and as this substance was allowed to evaporate before planting the seed, there was no decrease in germination with it. The wood ashes, while effective in checking the wilt, seemed to hurt the germination of the seed.

As some growers have seemed to have had some beneficial results with the use of lime on wilt infected soil, and as the greenhouse experiments seemed to show that it might be effective, some field experiments were tried in 1916. A piece of ground very badly affected with the tomato wilt was divided into three plots. One plot was left untreated as a check; to the second plot, unslaked lime was added, at the rate of five tons per acre; and to the third plot, lime at the rate of ten tons. In these plots were set five different varieties of tomatoes; two resistant varieties, Dwarf Stone and Globe; one early prolific variety, Earliana; and two very susceptible varieties, Acme and Stone. There were fifty-five plants of each variety in each plot. The plants, which all came from disease free seed beds, were set in the plots during the second week in April. In Table IV are given the results obtained in the experiment. By "percentage of apparent wilt" is meant the percentage of plants that showed external symp-

TABLE IV.

Effect of Lime on Development of Wilt in the Field.

Variety	Treatment	Percentage of Apparent Wilt			Total Yield in pounds
		May 25	June 2	June 9	
Dwarf Stone	Check	5.6	5.6	16.4	62.9
	Lime, 5 tons	1.8	1.8	3.6	73.8
	Lime, 10 tons	0.0	0.0	0.0	49.4*
Globe	Check	4.1	12.3	22.5	130.7
	Lime, 5 tons	5.8	5.8	9.6	146.1
	Lime, 10 tons	1.8	3.6	8.9	169.2
Earliana	Check	30.2	75.5	84.9	88.7
	Lime, 5 tons	16.1	46.4	66.1	102.5
	Lime, 10 tons	9.6	23.1	28.8	134.7
Acme	Check	60.4	77.4	90.6	7.9
	Lime, 5 tons	35.7	78.6	87.5	18.6
	Lime, 10 tons	15.4	40.4	61.6	21.5
Stone	Check	70.6	86.3	94.1	6.6
	Lime, 5 tons	38.0	60.0	84.0	14.9
	Lime, 10 tons	38.3	59.5	78.7	10.1†

*Outside row.
†Second row from outside.

toms of the disease. The absolute amount of wilt could only be obtained by cutting the plants.

The results obtained in the field tests bear out, in a remarkable way, the ones obtained in the greenhouse. In nearly every case, there was a decided decrease in the wilt percentage with the increase in the amount of lime. The heavy application of lime did not eradicate the disease but only seemed to delay its development for about two weeks. As a matter of fact, all of the susceptible plants in all of the plots finally died with the disease. The contrast in the appearance of the plots during the first part of June was very striking. In figure 7, are shown the Stone and Acme rows in the check plot, and in figure 8 the same varieties in the plot limed at the rate of ten tons to the acre. These photographs were taken on June 12, at the time when the plots showed the greatest contrast.

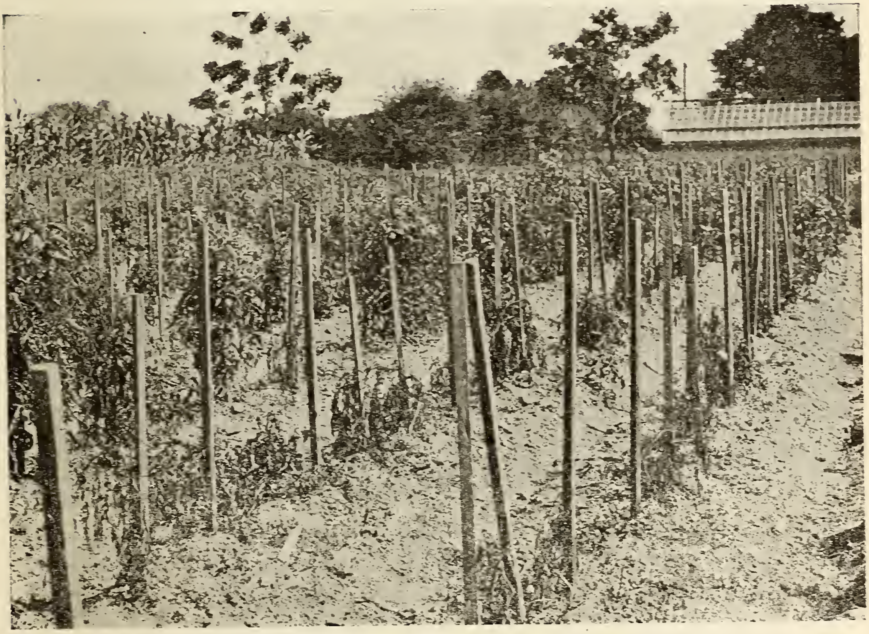

FIG. 7. Development of wilt in a badly infested field.

The first picking of fruit was made on June 9, the same day the last count of the wilt was made. The last picking was on

July 22. With two exceptions, there was a marked increase of fruit as the lime was increased and the wilt decreased. The exceptions were the rows of Dwarf Stone and Stone on the plot limed at the rate of ten tons to the acre. These were outside rows and did not have an equal chance with the others. As Bermuda grass had worked in from the side the soil was not in as good a state of cultivation.

The amount of wilt in the soil of the different plots was as nearly the same as is possible to have it. The plots were side by side and tomatoes had been grown on the ground for several years.

The application of lime did not seem to have any permanent effect on the soil. These plots were used for selection work the following year and no perceptible difference in the plants in the different plots was noticeable. Perhaps if susceptible varieties had been planted, there would have been a difference.

VIRULENCE OF DIFFERENT CULTURES.

A great many different cultures of *Fusarium lycopersici* have been isolated and studied since the work started. Most of these have come from plants grown in various parts of Louisiana, though a few have been obtained from Mississippi and Arkansas material. These cultures have been made by direct transfer from the interior of the stems and roots and also from spores that developed on old plants during different seasons of the year. Before carrying on any experiments with a culture, it is necessary to test it out in pots of sterilized soil in the greenhouse. This is necessary to determine the virulence of the culture and also to prove that the fungus is really *Fusarium lycopersici* and not some non-pathogenic Fusarium, that had found its way to the diseased tomato plants. Fusarium cultures that were not able to produce the disease in young plants have been frequently isolated from the inside of infected tomato plants. These have usually been discarded as it seemed probable that they were not cultures of *Fusarium lycopersici*. Also in a few of the tests, one or two plants would show some discoloration in the interior of the stems at the final examination. All such cultures were usually discarded as it did not seem probable that they were cultures of *Fusarium lycopersici*. The results from some of these tests, in which only one or two of the plants developed the disease, were included in a previous publication (5), but it now seems very questionable whether they should be considered.

While working on the disease and carrying on various experiments in the greenhouse, the questions of whether there is any great variation in the virulence of cultures and also whether some strains attack some varieties in preference to others, have been kept constantly in mind. As far as the cultures which have been studied are concerned no pronounced difference was found between any of them. Some cultures constantly showed less virulence than others, but this occurred with all varieties of tomatoes. A variety susceptible to one strain of the fungus was susceptible to all virulent strains, and a variety resistant to one strain, was resistant to all. Of course, the cultures which have been used were all from the Louisiana-Arkansas-Mississippi terri-

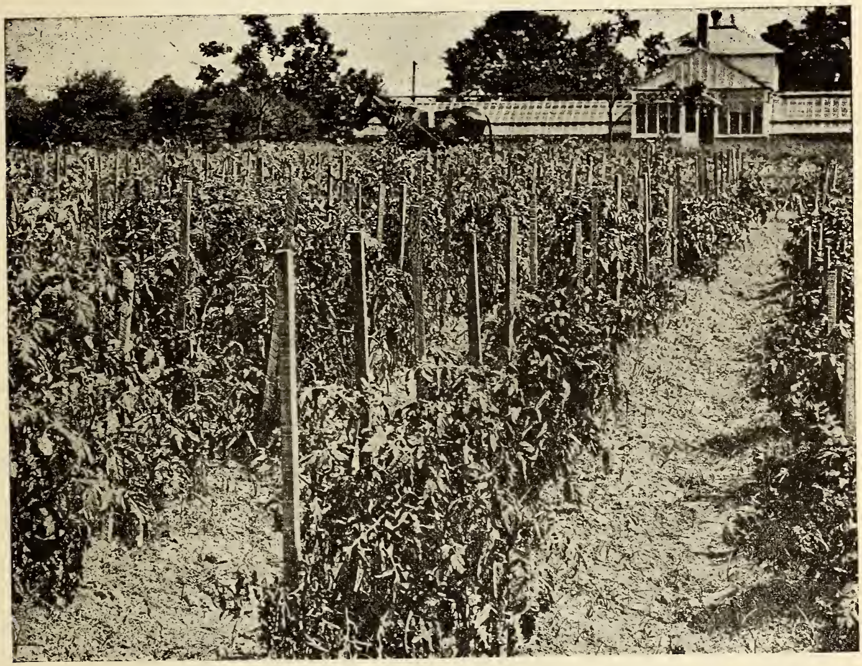

FIG. 8. Effect of lime on the development of tomato wilt. Soil had been treated with lime at the rate of ten tons to the acre. These rows were less than twenty feet from those shown in figure 7. Photograph made the same day.

tory, but it is doubtful if strains from other parts of the country would give any different results. Resistant varieties which have been developed in Louisiana have shown the same relative resistance when grown in Georgia, Ohio and at Washington, D. C.

Some cultures have shown a slight deterioration after being grown for some time in the laboratory but this has not been marked. Also some cultures have been kept growing for six years without showing any apparent deterioration. Some of the most virulent cultures growing in the laboratory in 1920 were isolated in 1914. The virulence was maintained whether the cultures were kept in the ice box or in an incubator at 28-30°C.

TEMPERATURE RELATION.

The effect of high and low temperature on the development and parasitism of a fungus is an interesting point in the study of its life history. In many cases, temperature is the determining factor in the distribution of a fungus. Some fungi are only found in the cooler climates, while others are only found in the warm tropical or subtropical climates. Others may be found in both climates but occur at different seasons of the year.

In studying a disease, a knowledge of the temperature relation of the causative organism is very essential. If this is not known, experiments will frequently be conducted at a wrong temperature and only negative results obtained. A number of examples of this have been observed in the work on various plant diseases at the Louisiana Station. While working with the angular leaf spot of cotton caused by *Bacterium malvacearum,* numerous infection experiments carried on in the greenhouse during the winter months were failures, but the same experiments carried on during the warm summer months were all successful. Also a number of experiments carried on with the tomato wilt during the early part of the work, before the importance of the temperature relation was realized, had to be duplicated.

A knowledge of the temperature relation may also be of extreme importance in controlling a disease in certain localities. The bean anthracnose, (4) caused by the fungus *Colletotrichum lindemuthianum,* will not grow at high temperatures. In the northern states, it develops best during the ordinary summer temperatures, but the summer temperature in Louisiana is too high for its development. Taking advantage of this, bean growers are raising a fall crop of beans for seed, this seed being used the following spring for planting the main crop. To obtain a fall crop of seed, the beans are planted in the hot summer months and the disease is entirely destroyed.

The relation of the tomato wilt fungus to temperature has received much consideration during the past several years at the Louisiana Station. That there was some relation existing between temperature and the development of the disease, was realized early. In carrying on the experiments in the greenhouse in pots, much better infection was obtained during the warmer months than during the winter. This seemed to throw some light on the distribution of the disease over the country and also showed why some of the workers in the northern part of the country had had trouble in obtaining good infection in young plants growing in heavily contaminated soil.

In order to obtain more definite information on the temperature relation of *Fusarium lycopersici*, a series of experiments were planned and carried through during the past few years. These experiments included studies of the rapidity of growth of the fungus in pure cultures, and of the infection and development of the disease in living plants at different temperatures.

While this work has been in progress, some studies on the same problem have been started by Clayton, (1) at the Wisconsin Station. While his method of carrying on the work has been different, the results obtained agree closely with those described in this bulletin.

GROWTH IN PURE CULTURES AT DIFFERENT TEMPERATURES.

Fusarium lycopersici grows very readily in pure cultures and consequently the effect of a single factor, such as temperature, is very readily obtained. A series of experiments was run in which several different strains of the fungus were used. A large batch of bean pod agar was made at one time, enough to complete a whole experiment. This prevented any variation in the media itself. Poured plates were made and after the agar was cooled, a small planting of mycelium from the edge of a rapidly growing culture was made to the center of each plate. The plates were then grown in the incubator at temperatures from 14°C to 37.5°C. Cultures were grown at intervals of from two to four degrees. For the lower temperatures a Hearson Low Temperature incubator was used and for the higher temperatures, electric controlled bacteriological incubators. The cultures were allowed to grow for from four to five days, the diameter of the colony being measured at the end of each twenty-four hour period. The growth for the first day was not considered in figuring the results. The average daily growth was obtained by averaging the results obtained in three plates. The fungus was not grown at all of the different temperatures at the same time, but this was not important, as the same batch of agar was used through the whole experiment.

In figure 9, is charted a curve showing the daily growth in millimeters of the fungus, *Fusarium lycopersici,* at the various temperatures. A number of different cultures were used, but

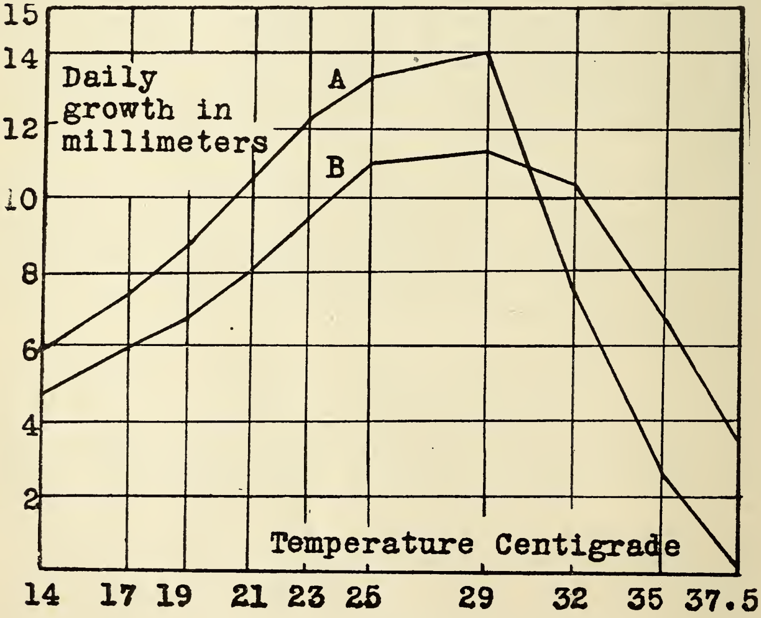

FIG. 9. Curves showing daily growth of cultures on bean pod agar at various temperatures. (A) *Fusarium lycopersici.* (B) A species of Fusarium isolated from diseased tomato stem, not *Fusarium lycopersici.*

as the growth of all was so similar, a composite curve is made for all of them. The curve shows that the optimum temperature for growth of *Fusarium lycopersici* is around 29° C.* The maximum temperature is slightly above 37.5°C. The minimum temperature was not obtained as the fungus was able to grow fairly well at the lowest temperature tried, 14° C. The curve shows that the rate of growth increased directly with the temperature until a point near the optimum was reached. Above this point, the growth decreased very rapidly.

As a comparison, several strains of the cotton wilt fungus, *Fusarium vasinfectum,* and one strain of the cabbage yellows fungus, *Fusarium conglutinans,* were included in the test. The curve of growth of the cotton fungus was found to be almost identical with the tomato wilt fungus but the cabbage fungus showed a slower growth at all temperatures.

There were also included in the test, some cultures of Fusarium that were obtained from tomato stems and at the time were supposed to be cultures of *Fusarium lycopersici.* The curve of growth of these forms did not coincide with that of *Fusarium lycopersici,* and they were later proven to be saprophytic forms by infection experiments. They were unable to produce the disease in young plants. The curve of growth of one of these cultures is shown in the figure. This shows the absolute necessity of testing the parasitism of any strain before attempting to carry on any experiments with it.

INFECTION EXPERIMENTS AT VARIOUS TEMPERATURES.

In order to test out the effect of temperatures on infection, a series of tests was run in one compartment of the greenhouse during the years 1918 and 1919. A large bench was filled with about twelve inches of garden soil and on this was placed a Friez thermograph, to register both soil and air temperature. The bulb for the soil temperature was placed about three inches deep in the soil. On every Wednesday, during a period of a year, six six-inch pots were filled with soil, sterilized in the autoclave, reinoculated with cultures of *Fusarium lycopersici* and planted with tomato seed. The soil consisted of two-thirds garden soil and one-third leaf mold. The soil was all mixed before the experiment started and was stored in the potting room of the greenhouse. This prevented any variation in the soil. Five different cultures of the tomato wilt were used. These cultures were grown on bean pods in tubes, and to each pot was added one tube of each culture. These cultures were thoroughly mixed into the upper layer of the soil in the pots. About one hundred tomato seeds were planted in each pot. The variety, Stone, was used as this is a very susceptible variety. Also seed for the whole set of tests was obtained from a single pound package. The pots were sunk in the soil in the greenhouse bench so that the temperature in the pots would coincide with the temperature of the soil in which the thermograph was placed.

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*Clayton (1) places the optimum at 28°C.

The first set was started on July 17, 1918, and the last one, June 11, 1919. During this period there was a great variation in the temperature of the soil and air. During the summer months, the temperature in the greenhouse was very hot, the air temperature often running to 110 or above and the soil temperature running above 100. During the winter only enough heat was used to prevent the plants being injured by the cold. With the exception of four sets started in November, 1918, the experiment was carried out as planned. The plants in these four sets were accidentally killed on December 18 by smoke from an oil stove that had been placed in the compartment to prevent freezing.

The first examination of the plants was made just fourteen days after the seed were planted. Following this, they were gone over carefully once or twice a week until the test was ended. The tests continued for seven or eight weeks after planting. The presence of wilt in the plants was determined by holding them up to the light. All plants showing a black center were pulled and counted, even if the leaves did not show signs of the disease. At the last examination, all the remaining plants were pulled and the stems cut. This gave the actual percentage of wilt at the end of the test.

At the end of each test the data obtained included a complete record of the soil and air temperature and the percentage of diseased plants at the end of each week. In Figure 10 is given a summary of the results of all the tests. Curve A shows the mean of the maximum air temperatures for the days of each

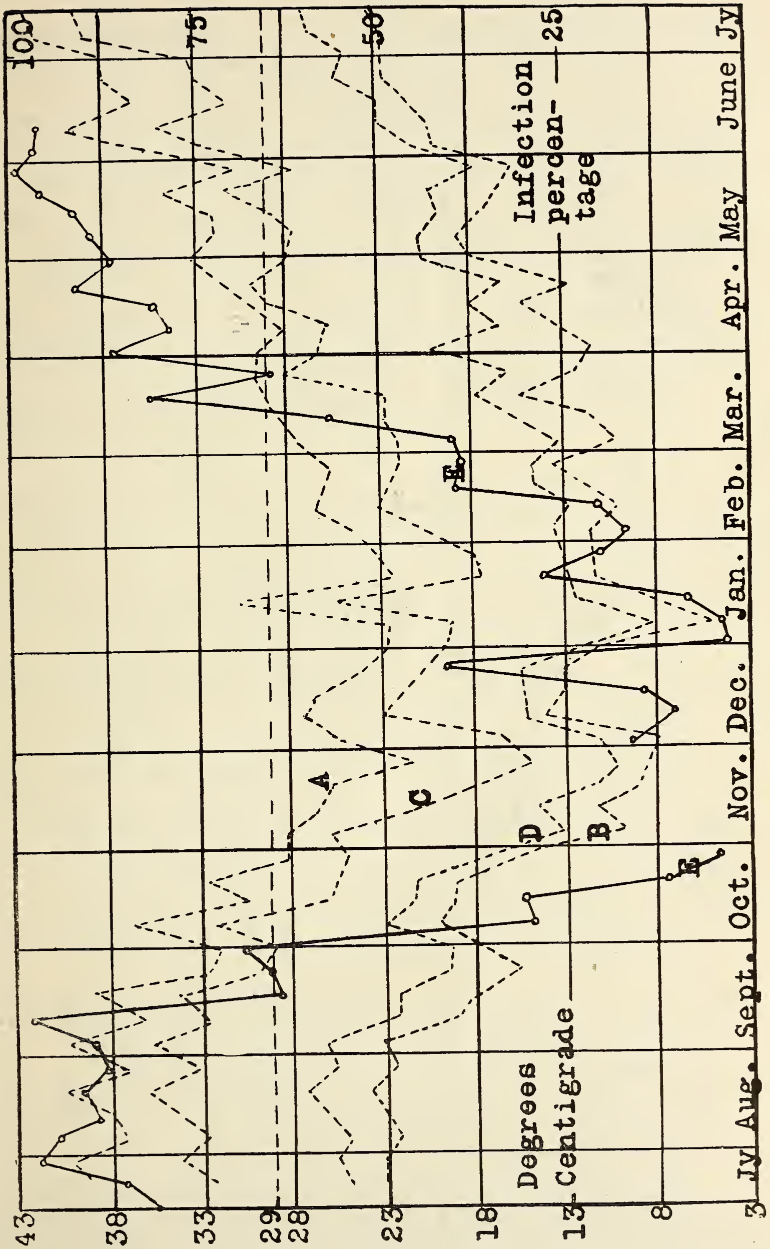

FIG. 10. Curves showing mean maximum and minimum soil and air temperatures or weekly periods from July, 1918, to July, 1919, and the percentage of wilt in reinoculated sterilized soil during the same period. (A) Mean maximum air temperature. (B) Mean minimum air temperature. (C) Mean maximum soil temperature. (D) Mean minimum soil temperature. (E) Infection percentage. The date of the beginning of each test is marked by a circle. Consequently each test ran through a period of seven or eight weeks following the location on the curve.

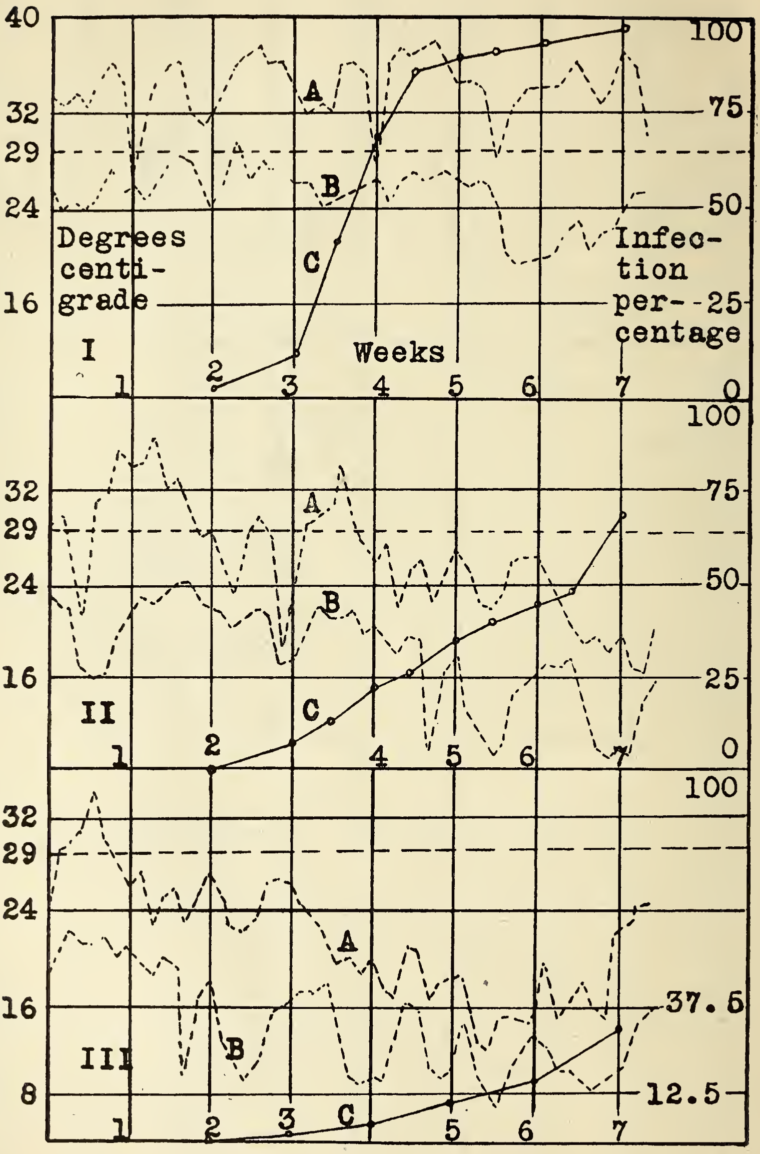

FIG. 11. Development of wilt in reinoculated sterilized soil at different seasons of the year. (A) Daily maximum soil temperature. (B) Daily minimum soil temperature. (C) Infection percentage at different periods after planting, each circle representing the date of examination. (I) Experiment started July 24, 1918. (II) Experiment started September 25, 1918. (III) Experiment started October 16, 1918.

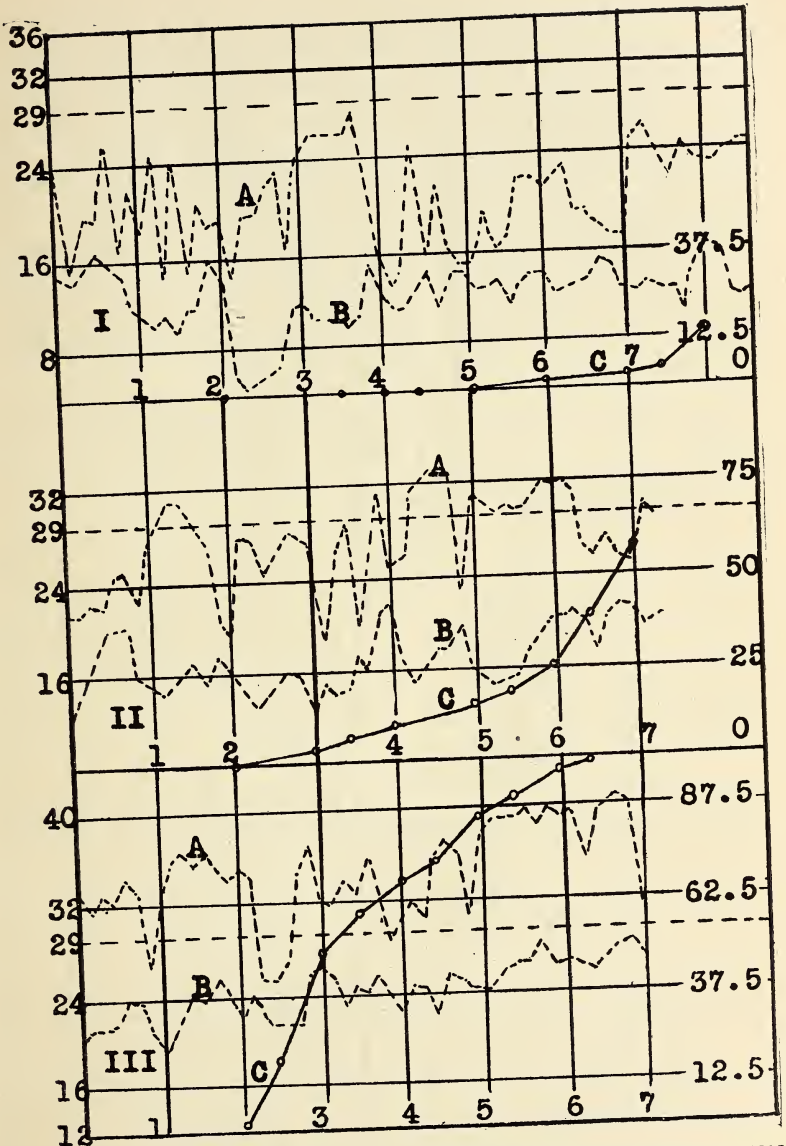

FIG. 12. Continuation of figure 11. (I) Experiment started December 18, 1918. (II) Experiment started March 12, 1919. (III) Experiment started May 28, 1919.

week; Curve B shows a similar mean for the minimum air temperatures; Curve C shows the mean of the maximum soil temperatures for each weekly period; and Curve D shows the mean of the minimum soil temperatures for each week. In Curve E is shown the total percentage of infection for each test. The position of the circle in each case represents the date on which the seed were planted. Consequently each test ran through the seven or eight weeks following its location in the curve. The optimum temperature for growth of the fungus, 29°C, is shown by a broken line. The effect of temperature on infection with *Fusarium lycopersici* is brought out in a very striking manner by these curves. While the soil temperature is around the point of optimum growth for the fungus, the infection runs from 85 to 98% but in those tests in which the soil temperature was below this, the infection percentage was very low.

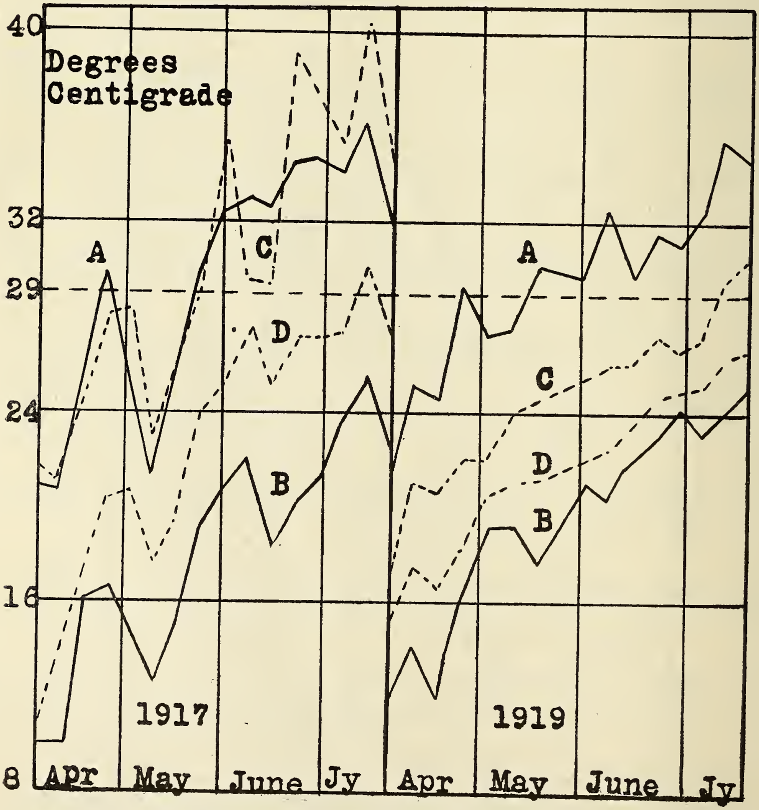

FIG. 13. Curves showing mean maximum and minimum soil and air temperatures in the field for weekly periods during the growing seasons of 1917 and 1919. (A) Mean maximum air temperature. (B) Mean minimum air temperature. (C) Mean maximum soil temperature. (D) Mean minimum soil temperature.

To bring out more clearly the effect of temperature, in figures 11 and 12 are shown graphically, the rate of infection in six of the individual tests run at different seasons of the year. As the soil temperature seems the most important factor in the infection, the air temperature is not included in the curves. The daily maximum and minimum soil temperatures are shown in the curves, and also the percentage of infection at all times during the test. Each small circle shows the date on which the plants were examined and the diseased ones counted.

It will be noticed from these curves that while the maximum soil temperature remains considerably above the point of optimum growth of the fungus, and the minimum temperature is not far below, as in figures 11A and 12C, the infection percentage rises very rapidly from the second week after planting. When the maximum and minimum soil temperatures are both constantly below the optimum temperature, as in figure 12A, the infection percentage remains very low. At other times, when the maximum soil temperature is sometimes below and sometimes above the optimum, the curve of infection is intermediate between the other two extremes.

To obtain good infection it would seem that the temperature of the soil should remain somewhere in the neighborhood of the optimum temperature for growth of the fungus.

Clayton (1) has shown that with soils kept at constant temperatures the best infection is obtained at the temperature of optimum growth and that the infection decreases as the temperature goes above or below. His data do not show the effect of the constant changes which take place in the soil temperature. From the experiments described in this bulletin, it does not seem that the daily change in temperature is so important. If the mean daily soil temperature remains close to the optimum for growth of the fungus, the highest infection percentage results.

It is of interest to compare the results obtained in the greenhouse to conditions in the field. In figure 13 are charted curves showing the temperature of the soil and air in the principal tomato growing months of the years 1917 and 1919. The air temperatures are shown by solid lines and the soil temperatures by broken lines. The upper curve in each case represents the mean of the daily maximum temperatures for each week while the lower represents the mean of the minimum temperatures. There is a considerable difference between the soil temperatures of the two years. In 1917, the soil was freshly prepared and was kept free of grass while in 1919, the temperature was obtained under a grass sod. Consequently it is apparent that the curves for 1917 represent more nearly the soil conditions in a cultivated field. It would seem from the temperature curves for 1917 and the results obtained in the greenhouse that the soil reaches the optimum temperature for the development of the disease about the middle of May or shortly after.

In the field, tomato plants do not usually begin to show the effect of the disease until the middle of May. In figure 17 are charted curves showing the development of wilt in different varieties in the field during 1919. Even with the most susceptible varieties, as illustrated by curves marked 9 and 10, there was but a small percentage of wilt on May 20, but the percentage increased rapidly after that date. There is, however, another factor to be taken into consideration. As the plants were healthy when they were set in the field during the first week in April, it would naturally take some time for the disease to develop sufficiently to injure them. Yet it would seem that seven weeks is longer than is necessary for this. The rapid development of the wilt after the middle of May, when the soil temperature has reached the optimum for the fungus, indicates that the temperature is an important factor in the field as well as in the greenhouse.

SELECTION FOR WILT RESISTANCE.

It has been recognized for some time that different varieties of plants or different strains within a variety are often more resistant to certain diseases than other varieties or strains. This seems to be especially true with plants that are affected with Fusarium wilt diseases. Since this fact has been recognized, much attention has been given to the selection of wilt resistant strains by various plant breeders and pathologists. At present there are a number of wilt resistant strains of cotton, cabbage and tomatoes. In the South, wilt resistant varieties of cotton are being grown over large areas.

The development of wilt resistant strains of tomatoes is more recent than that of cotton varieties. However, a number of such strains have been developed within the past ten years by the various experiment stations and by the United States Department of Agriculture.

At the Louisiana experiment station, this work was first started in 1910. In that year, individual selections were made from a badly infected field of Acme tomatoes. One of the plants seemed to be especially wilt resistant, as it lived through the whole season without showing any traces of wilt. Of the seed saved that year, only that from this one plant showed any resistance the following year. In 1911, the unselected Acme showed a wilt percentage on June 13, of 52%, while the plants from this selection only showed 10.3%. Although this plant was selected from a field of Acme tomatoes, it is possible that it did not really belong to this variety, as the fruit and plant differed in some respects from the ordinary Acme type. The strain which was developed from this plant has gone under the name of "Louisiana Wilt Resistant" in publications from the Louisiana station.

The Louisiana Wilt Resistant tomato was grown for several years, seed being saved each year from individual plants that were the most resistant to the disease and the most prolific. Some of the seed at different times, was distributed to growers in Louisiana and other states. This tomato showed a high percentage of resistance wherever it was grown. In the tests at the Ohio station (7) none of the plants took the wilt. However, this tomato was not a satisfactory variety for Louisiana conditions. It was late in maturing and was a light yielder.

In order to improve on the strain, in 1912 crosses were made between this wilt resistant strain and Langdon's Earliana, an early, high yielding variety. These hybrids have been grown for several years, selections being made each year for wilt resistance and also for other desirable qualities. Two strains have been obtained which are fairly resistant and in other ways, are more desirable than the original resistant strain. Neither strain is as resistant as the original Louisiana Wilt Resistant, yet both are as resistant as any of the resistant varieties which have been tried. In this bulletin, these strains are listed under the names of Louisiana Red and Louisiana Pink. (See figure 14).

In a climate where conditions are at the optimum for the development of the wilt, such as that of Louisiana, a plant that is susceptible at all will develop the wilt. As a matter of fact, a large percentage of the plants of the most resistant strains, will show the wilt if they are examined closely. The wilt seems to develop slower in a resistant strain and the plants do not die as rapidly. It would really be better to call these strains "tolerant" rather than "resistant."

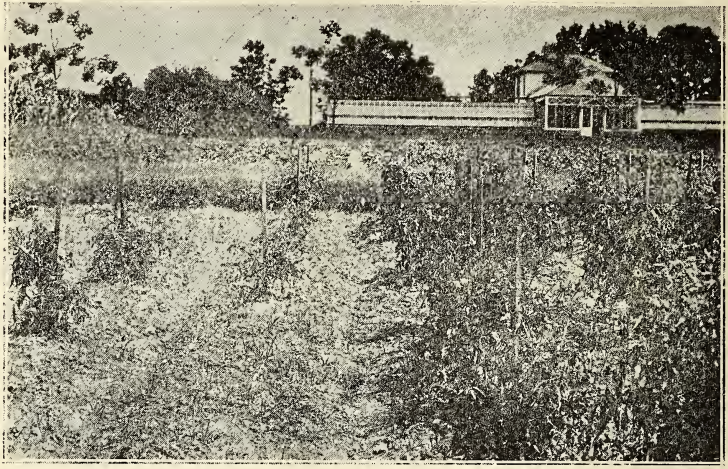

FIG. 14. Results of selection for resistance to tomato wilt. All the plants were grown in reinoculated sterilized soil in the greenhouse. The rows on the left were transplanted with susceptible varieties, while the rows on the right were set with the resistant Louisiana Red selection.

The selection work has been greatly aided by the seed bed method of selecting plants. This method eliminates a great many of the most susceptible plants before they are set in the field.

As the tests of these resistant strains have been mostly carried out in conjunction with the varietal tests, these will be considered in the next section of this bulletin.

VARIETAL SUSCEPTIBILITY.

During the past several years, a large number of different tomato varieties have been grown on badly infested soil in the field and in reinoculated, sterilized soil in the greenhouse and the opportunity has been available to obtain some idea of the comparative resistance of the different ones. These tests have not always been made under the same conditions or with the same varieties, but enough information has been obtained so that the relative resistance of the different varieties is fairly accurately known.

GREENHOUSE EXPERIMENTS.

Some of the results which have been obtained in the greenhouse with sterilized soil are given in Table V. In all of these tests, the plants were grown in six-inch pots and the soil was sterilized in the autoclave and heavily inoculated with pure cultures of the tomato wilt fungus just previous to planting. Five tests are given in the table. In the different ones, the temperature was the principal varying factor though it is probable that there was some slight variation in the soil. All the soil in each test was mixed together before it was placed in the pots. Some of these tests were run before the real effect of temperature was realized and the effect of low temperature is very evident in some of them.

The date on which each test was started is given in the table. The tests started in December 1918, and January 1919, were run at too low a temperature and the results are not very satisfactory. The test started in September, 1919, was run under the best temperature conditions and the results obtained are the most satisfactory of any given in the table. The last seven varieties of tomatoes listed are ones which have been selected for wilt resistance, all others being commercial varieties.

In all of the tests, the diseased or dead plants were pulled and counted at intervals of three to ten days, and at the final examination all plants were pulled and cut, and all that showed blackened fibrovascular bundles were counted as diseased.

The table shows that all varieties, even the most resistant, when grown under the most favorable conditions, show a rather heavy infection with the wilt disease. Susceptible varieties, however, take the wilt earlier, die quicker, and in most cases, show a higher infection percentage than resistant ones. The susceptibility of the Stone variety is well brought out in all of the tests in the table.

Some of the tests given in table V were continued too long to show the widest difference between susceptible and resistant

TABLE V.

Resistance of Different Varieties in Reinoculated Sterilized Soil.

VARIETY	Percent of Diseased Plants.				
	January 1915	January 1916	December 1918	January 1919	September 1919
Stone	100.0	79.3	28.6	44.9	100.0
Bonny Best			11.4		93.4
Chalk's Early Jewel		78.2	3.5		97.3
Acme	97.5	57.6			
Beauty		78.0			
John Baer		75.3			
Magnus		55.1			
Early Detroit		54.3			
My Maryland		52.5	5.3		
Greater Baltimore		48.3			
Dwarf Stone		41.3			
Prosperity		38.8			
Earliana	88.5	38.1	18.3		95.7
June Pink			10.5		96.2
Manyfold			1.4		
Globe		30.4	3.9	26.9	94.9
Columbia				25.2	76.2
Arlington				14.7	84.2
Norton				38.5	83.1
Marvel				17.6	86.1
Louisiana Pink				26.7	82.4
Louisiana Red			2.8	12.7	86.0
Louisiana Wilt Resistant	56.5	21.6			

varieties. In experiments of this kind, the longer the test runs, the less difference will be seen between the resistant and susceptible varieties. This is brought out clearly by obtaining the wilt percentage at short intervals after the plants come through the ground. In figure 15, are charted curves showing the development of the wilt in the experiment started in September, 1919. The curves show the percentage of wilt in each variety, from the twenty-first day after planting until the test was completed on the fifty-ninth day. Curves 1 to 6 represent resistant varieties, while curves 7 to 12 represent commercial varieties.

While the resistant varieties show less wilt all through the

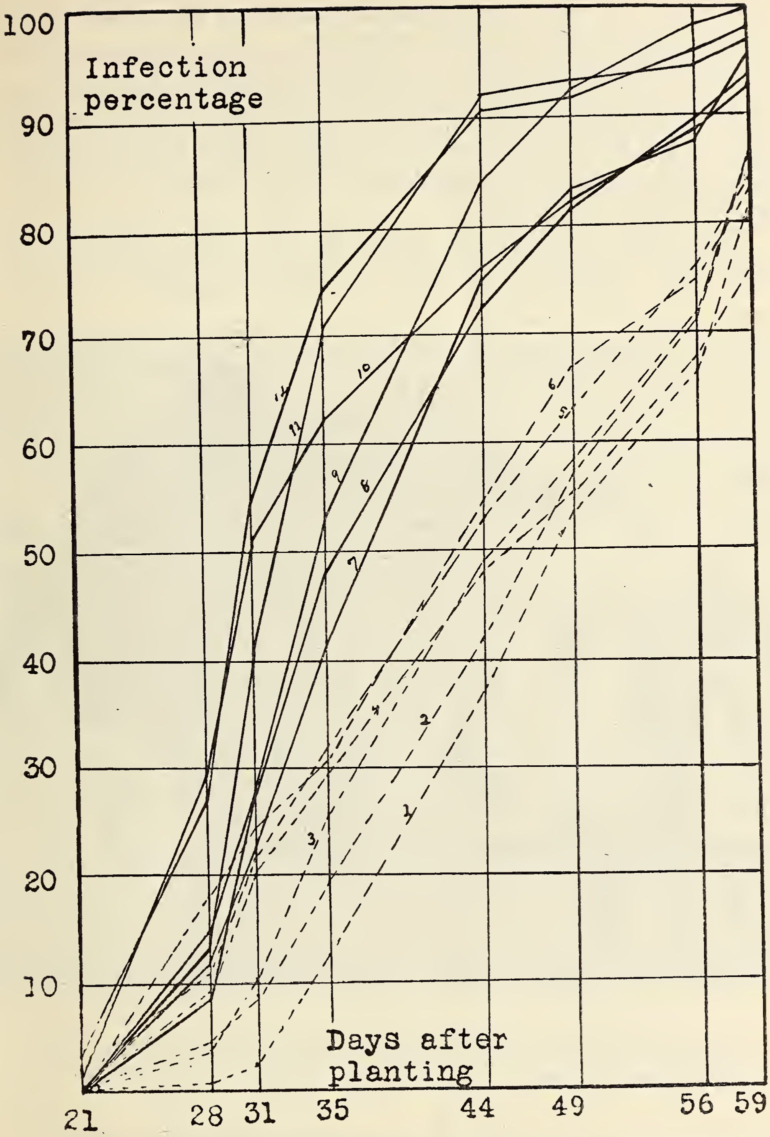

FIG. 15. Curves showing percentage of wilt in different varieties in reinoculated sterilized soil in greenhouse, 21 to 59 days after planting, test started in September, 1919. Curves 1 to 6 are selected resistant varieties, curves 7 to 12 are commercial varieties. See figure 18 for names of varieties.

experiment, on the forty-fourth day there was the greatest difference between the two sets. At that time the resistant varieties showed a wilt percentage of between 38 and 55%, while the commercial varieties ranged between 73 and 93%. With the exception of the Globe, which shows a higher infection percentage than usual, the results obtained in this test agree well with various other variety tests.

The relative resistance of different varieties is well brought out in the illustration in figure 16. There is shown a pot, in which seed of a resistant and of a susceptible variety were planted in reinoculated sterilized soil. At the time the photograph was taken, most of the resistant plants were still in good condition though practically all of the plants of the susceptible variety were dead.

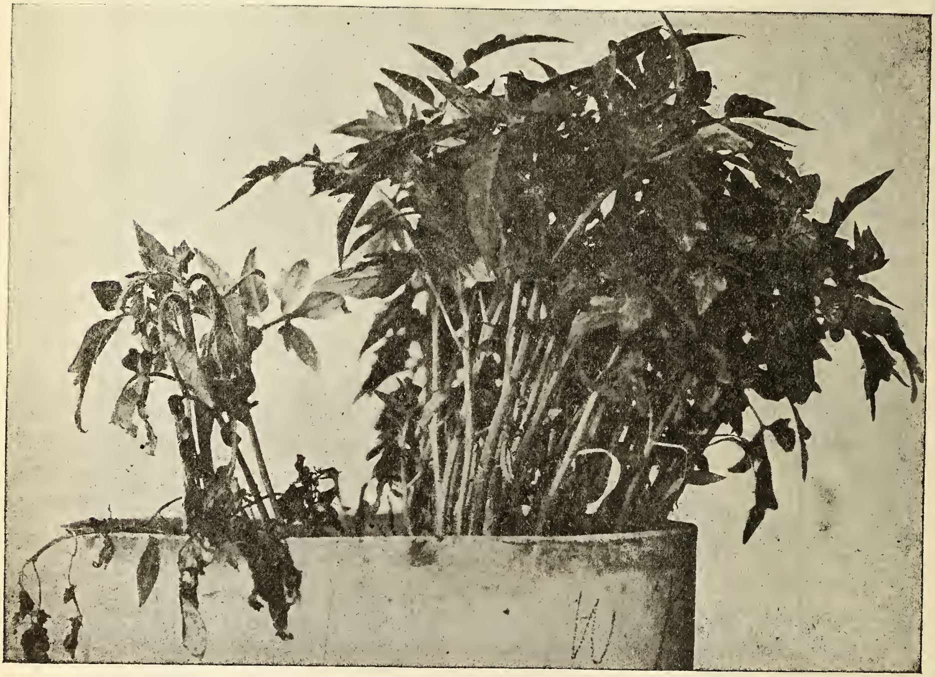

FIG. 16. Comparison of a susceptible and a resistant variety of tomatoes in reinoculated sterilized soil. In the left half of the pot was planted a susceptible variety, Acme; in the right half was planted a resistant variety, Louisiana Wilt Resistant. Most of the plants of the susceptible variety are dead.

FIELD EXPERIMENTS.

In the field work on tomato wilt a great many different tomato varieties have been grown at various times on badly infested ground, though it has not been practical to carry out many extended variety tests. Only a limited amount of badly infested ground has been available and this has mostly been required in the selection work. It is not worth while to carry out a variety test on ground that is not badly and evenly infested with the wilt fungus. However, tests carried on during two years, using both resistant and susceptible varieties, combined with the many miscellaneous experiments, have yielded results worthy of mention and have shown the relative resistance of the various varieties.

In 1916, a field test was run in which five varieties were used. These included two resistant varieties, Globe and Dwarf Stone; two very susceptible varieties, Acme and Stone; and one early fruiting susceptible variety, the Earliana. These varieties were planted in two different fields. One of the fields had grown tomatoes continuously for a number of years and was very badly infested with the wilt. Other than this, the field was in a very good state of cultivation and the tomato plants were staked and were well taken care of. The other field had never grown tomatoes and consequently was free of the wilt. This latter field, however, was in a very poor state of cultivation. The ground was not well drained and on account of temporary labor conditions, it was not possible to stake the plants and care for them properly. On this account, it would be expected that the wilt-free field would not give a satisfactory yield. However, the results are included because the comparative results with the different varieties are reliable. In this experiment, the total yield of fruit was obtained and also the percentage of wilt in the infested field on two different dates. The last date was at the time the first picking of fruit was made. The results are given in Table VI.

According to this table, the yield of the resistant varieties, Dwarf Stone and Globe, was six to seven times greater on the wilt infected plot than on the wilt free plot. This was due entirely to the fertility of the plot and the better cultivation. The effect of wilt on susceptible varieties is seen in the yield of the

TABLE VI.

Comparison of Different Varieties in the Field in 1916.

Variety	Wilt-infested plot			Wilt-free plot, poorly cultivated.
	Yield per acre Pounds	Infection percentage May 25	Infection percentage June 9	Yield per acre, Pounds
Dwarf Stone	7550	10.9	16.4	1260
Stone	790	70.6	94.1	3450
Acme	950	60.4	90.6	1850
Globe	15690	4.1	22.5	2100
Earliana	10670	30.2	84.9	4750

Stone and Acme. While these tomatoes averaged more on the wilt free soil than the resistant varieties, on the infested soil the yield dropped very low, producing less than a thousand pounds to the acre. If the wilt had not been present in the plot, judging from the increased yield of the Globe and Dwarf Stone, it is probable that the Acme would have produced from 10,000 to 18,000 pounds on the good soil. The Earliana, which produces an early crop, before the wilt has time to kill the plants, produced a fair crop on the wilt infested soil, though the yield was one-third less than the Globe, while on the wilt free soil, it was twice as large.

The wilt percentage was much greater in the Stone and Acme varieties than in the Globe and Dwarf Stone. The Earliana showed less wilt than the susceptible varieties, but considerably more than the resistant ones.

In 1919, a field test was run, using a larger number of varieties. The experiment was started in order to obtain information on the value of a number of resistant varieties which have been selected during the past few years, these being compared with a number of the standard commercial varieties. The plot used had grown tomatoes for several years and was badly infested with the wilt. The plants were set in the field in a manner to eliminate as far as possible, the effect of any slight variation in the soil. A row of each variety was planted and then this order of planting was duplicated four times, thus making five rows of each variety in different parts of the plot. The plants were all healthy when they were set in the field. The results obtained are given in table VII. These include the yield per acre, the percentage of plants showing injury by the wilt disease on June 25, and the percentage of plants actually affected on July 11, this being determined by cutting each plant.

TABLE VII.

Comparison of Different Varieties in the Field in 1919.

Variety	Yield, tons per acre	Apparent wilt June 25	Actual wilt by cutting, July 11
June Pink	5.9	60.1	96.6
Earliana	5.7	47.6	87.6
Louisiana Pink	5.4	6.3	69.3
Louisiana Red	5.2	6.2	62.2
Arlington	5.1	13.2	77.7
Marvel	4.6	6.6	55.7
Norton	4.5	5.0	70.0
Columbia	4.3	15.0	75.4
Manyfold	4.2	24.5	90.7
Globe	4.0	1.2	77.9
Bonny Best	3.6	80.6	97.2
Chalk's Early Jewel	3.4	58.4	92.7
Stone	1.7	78.3	96.1

The results given in table VII coincide very well with those from other tests and also with various observations that have been made during the past ten years. The point of chief interest are as follows:

(1). None of the varieties were really wilt-resistant as wilt was found in a high percentage of the plants of all the varieties when the stems were cut open and examined. However, the wilt did not develop as rapidly in some varieties as in others nor did it kill the plants as quickly.

(2). The varieties showed considerable variation in regard to the percentage of plants killed or injured before a satisfactory crop of fruit was made. The so-called wilt resistant varieties showed a small percentage injured on June 25, while the percentage with some of the other varieties was high.

(3). The very early varieties, Earliana and June Pink, being healthy when set in the field, made a part of a crop before the wilt had time to materially injure the plants. In this test, these varieties made higher yields than any of the other varieties.

(4). The wilt resistant varieties produced a fair crop of fruit, though they were not as prolific as varieties of the Earliana type. The two Louisiana selections produced slightly more than strains selected in other parts of the country.

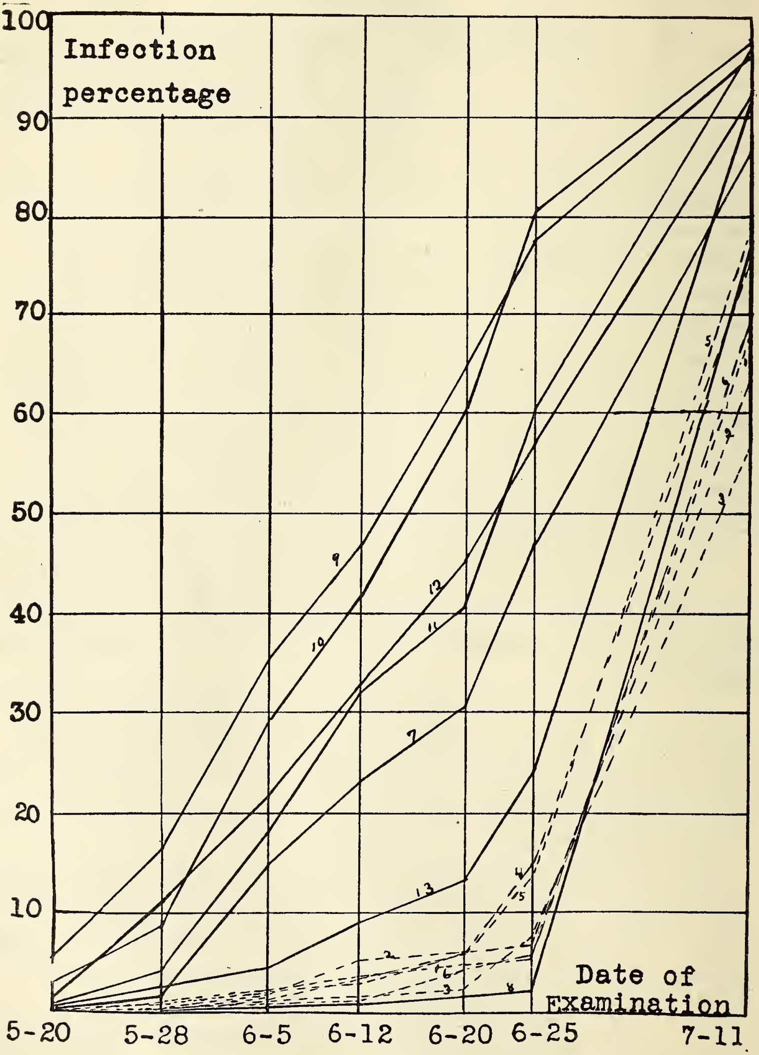

FIG. 17. Curves showing percentage of wilt in different varieties in the field at different dates in 1919. Last percentage was obtained by cutting the plants. Curves 1 to 6 are selected resistant varieties; curves 7 to 13 are commercial varieties. See figure 18 for names of varieties.

(5). The Globe was the most resistant of the commercial varieties but it made a light crop of fruit.

(6). The Stone was the most susceptible to the wilt and produced the poorest crop of fruit, of any of the varieties. This conclusion is in perfect agreement with a large number of observations and reports on this variety, from all over the State. The enforced use of this variety has hindered considerably the work of the girls' clubs throughout the State.

Had the tomato seed for this experiment been planted in seed beds infested with the tomato wilt disease, undoubtedly very different results would have been obtained. Under such conditions, the yield of the Earliana and June Pink varieties would undoubtedly, have dropped to a considerable extent. Plants of these varieties when taken from infested seed beds almost invariably produce a very poor crop.

In the 1919 tests, the wilt percentage was obtained at frequent intervals throughout the season. In figure 17, the curves show the percentage of wilt in the several varieties on different dates. On July 11, all the plants were cut and the stems examined, consequently the actual percentage is given for that date. On the other dates the percentage was obtained by examining the plants without cutting. A plant showing any effect from the wilt was classed as diseased. The curves are made in the same way as the ones in figure 15, which showed the development of the disease in the greenhouse, broken lines for the selected resistant varieties and solid lines for the commercial varieties. With the exception of the addition of the Manyfold in the field test, the same varieties and the same lots of seed were used in both experiments. The curves show that there was very little apparent injury to the selected varieties and also the Globe during the first part of the season, though the final examination showed a rather high percentage of the disease in the stems. With the susceptible varieties, the infection percentage rose rapidly from the time the temperature conditions were satisfactory. In fact, with varieties of the Stone type, the curves become almost straight lines.

Another point that is worthy of consideration, in a tomato variety experiment, is that of the time of the ripening of the fruit. In a section that grows tomatoes for the early market, a period of a week or ten days delay in ripening is of considerable importance. In the 1919 experiments, the picking season continued through five weeks. In figure 18 is shown the amount of fruit of each variety picked each week. The curves for the selected resistant varieties are made with broken lines, while those for the commercial varieties are made with solid lines. Two things of importance are shown by these curves. The wilt resis-

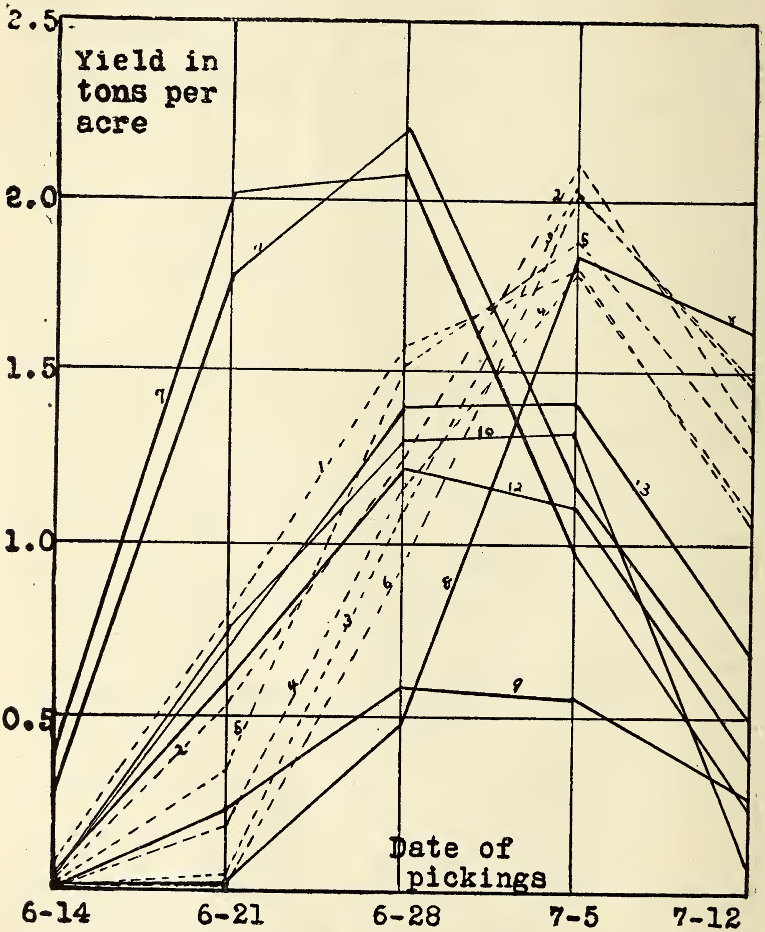

FIG. 18. Curves showing the amount of fruit picked per week from differnet varieties in 1919. Curves 1 to 6 are selected resistant varieties; curves 7 to 13 are commercial varieties. (1) Louisiana Pink; (2) Louisiana Red; (3) Marvel; (4) Columbia; (5) Arlington; (6) Norton; (7) Earliana; (8) Globe; (9) Stone; (10) Bonny Best; (11) June Pink; (12) Chalk's Early Jewel; (13) Manyfold.

tant varieties, Norton, Marvel, Arlington, Columbia, and Globe, are seen to be from a week to ten days later than the early varieties, Earliana and June Pink, while the Louisiana selections are intermediate. Also it is seen that with all of the susceptible varieties there was a decline in the yield after the third week, while the decline with the resistant varieties did not come until after the fourth week.

VARIETY TESTS IN OTHER LOCALITIES.

In 1919, variety tests in which the Louisiana selections were included, were run at a number of places in the country. By permission of the authorities at the different places, the tests made by Mr. J. A. McClintock at Experiment, Georgia, and by F. J. Pritchard of the United States Department of Agriculture, at Washington, D. C., are included.

In the Georgia test, a number of selections from various parts of the country, as well as several commercial varieties were used. The plants were set in the field on May 7, from non-infested seed beds. On July 3, the plants were examined by Mr. McClintock and the percentage of plants showing evident signs of

TABLE VIII.

Variety Test at Georgia Experiment Station, Season of 1919.

Selected Strains			Commercial Varieties		
Variety	Source of Seed	Percent Wilt, July 3	Variety	Source of Seed	Percent Wilt, July 3
Norton	Pritchard	0	Earliana	Hastings	88
Louisiana Red	Edgerton	0	Alacrity	Canada	74
Illinois Selections	Durst	0	Acme	Hastings	67
Duke of York	Ga. Station	3	Redfield Beauty	Hastings	92
Greater Baltimore	Temple	6	Chalk's Early Jewel	Hastings	100
Stone	Temple	7			
Marvel	Pritchard	13			
Arlington	Pritchard	14			
Beauty	Ohio Station	17			
Globe	Ga. Station	20			
Columbia	Pritchard	30			
Greater Baltimore	McClintock	50			
Beauty	Essary	60			
Bonny Best	Ohio Station	80			

the disease was obtained. The condition of the plants on that date are given in Table VIII. All of the plants of both the selected and commercial varieties died before the growing season was completed.

The results obtained at Washington, D. C., by F. J. Pritchard are given in Table IX. Plot No. 1 was on the Arlington Flats on very low and wet ground. Plot No. 2 was on the Arlington Farm. The number of plants with wilt was determined by cutting the plants and examining the stems for the dark color.

TABLE IX.

Variety Tests at Washington, D. C., Season of 1919.

Variety	Plot No. 1			Plot No. 2		
	Number of Plants	Number with Wilt	Number dead	Number of Plants	Number with Wilt	Number dead
Arlington	30	30	0			
Columbia	32	31	1			
Norton	47	41	0			
Marvel	32	27	0	32	8	0
Louisiana Red	32	29	0	15	4	0
Louisiana Pink	32	31	0	12	9	0
Red Head	16	16	15	16	15	9
Greater Baltimore	16	16	15			
Stone	16	16	16			
Bonny Best	16	16	16			
Earliana	16	16	16			
Globe	16	16	2			

The results of the Washington tests are very similar to those usually obtained in Louisiana. Even the most resistant varieties show a high percentage of wilt when the inside of the stems are examined for the dark color though the resistant varieties remain alive much longer than the susceptible ones.

In the tests, both at Washington, D. C., and in Georgia, the Louisiana selections showed as much resistance as the best of any of the other selections. This would seem to show that a resistant variety which has been selected in a climate which is very favorable to the disease, will show the same resistance in other parts of the country. It also tends to disprove the suggestion that there may be different strains of the wilt fungus in different parts of the country.

GENERAL CONCLUSIONS ON VARIETAL RESISTANCE.

From the investigations which have been carried on with tomato varieties and from observations that have been made at various times several conclusions have been reached which seem to cover our present knowledge and ideas of varietal resistance to the tomato wilt. These include the following:

(1). Strains or varieties have been selected which show a certain resistance to the tomato wilt, yet under favorable conditions, the most resistant plants will take the disease and die.

(2). The resistance is shown by the length of time it takes the disease to kill the plants; a susceptible plant dies rapidly, while a resistant plant may live several weeks after it becomes infected.

(3). There is no doubt but what the disease materially decreases the yield of even the most resistant strains.

(4). Under Louisiana conditions, resistant varieties are not usually very prolific though on badly infested soil they usually outyield most of the susceptible varieties. An early, prolific and resistant variety has not as yet been produced.

(5). The temperature factor may be of importance in some localities in determining the resistance of some strains. A resistant strain might be selected in a cooler climate that would not stand up when grown in a warm favorable climate.

CONTROL MEASURES.

In order to control the tomato wilt satisfactorily in a climate favorable to the disease, and in a locality in which the soil is badly infested, several things must be taken into consideration. These include a proper rotation, seedbed sanitation and the use of resistant and early varieties. All of these are important and all must be practiced in order to obtain a satisfactory crop. Following the recommendations regarding any one and paying no attention to the others will not bring satisfactory results.

ROTATION.

While the tomato wilt will not infect any plant except tomatoes, it will remain alive in the soil for some time without the proper host plant. Just how long the fungus will remain alive in the soil is not known, but it is evident that most of it is dead by the third or fourth year. In the rotation, then, to be recommended, tomatoes should not be put on the same ground more than one year out of three, and one year out of four would be more desirable. Also during the years that tomatoes are not being grown in a field, it is very essential that no infectious material from around packing sheds or other places should be placed on the soil and the field should not receive the wash from other ground on which tomatoes are growing. If there is no outside infection and a three or four year rotation is practiced, the disease will be decreased to such an extent that what little remains will not damage the crop to any considerable extent.

SEED BED SANITATION.

Particular care should be taken to keep the tomato wilt fungus out of the seed beds and cold frames; this is important whether the plants are to be set in an infested field or in one that is disease free. Plants that are kept free of the disease until they are large and ready to go into the field, will produce much more even in infested soil than those that have become infected in the seed bed. If the seed bed is badly contaminated with the disease, there is but small chance of raising a crop of tomatoes in any field. The result of planting tomatoes in a seed bed that is infested with the wilt is shown in figure 19. The row on the left was set from an infested seed bed, while the row on the right was set from a disease free bed.

Growers very frequently either keep the old soil in the seed bed from year to year, or else obtain fresh soil from a nearby garden or cultivated field. Either of these practices is liable to lead to trouble and should not be followed. The soil for the seed bed should be obtained from some place that is some distance from any field that has ever grown tomatoes or has received the wash from tomato fields. Soil from new ground is to be preferred. The seed beds, themselves, should be located on high ground and some distance from packing sheds and tomato fields. If possible, it is desirable to change the location of the seed beds from year to year. If this is not possible, the old soil should be thoroughly removed from the beds and all the frames and wood work disinfected with formaldehyde or some other good disinfectant before refilling.

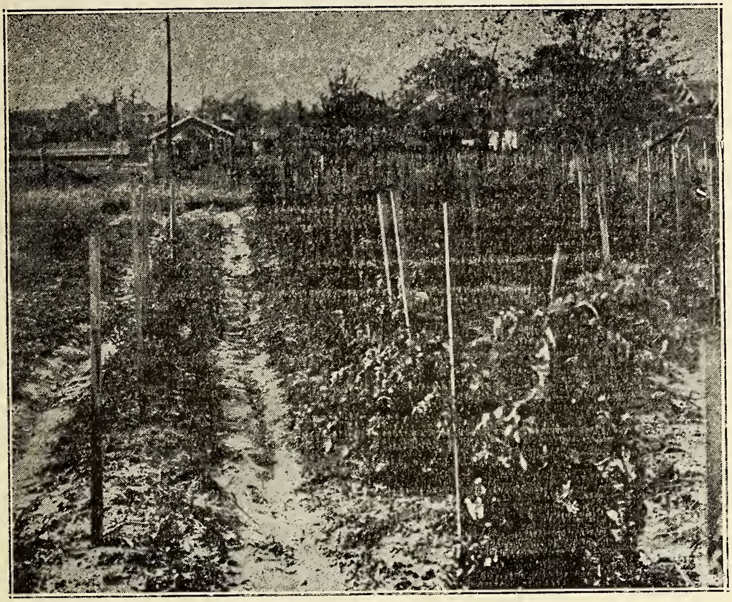

FIG. 19. Effect of setting plants from infested seed beds. Row on the left from an infested bed and the row on the right from a disease free bed. Most of the plants in the first row are dead.

There is another practice among some growers and gardeners that often leads to serious results, that is, the practice of buying plants instead of growing them. This is especially common with those who only require a few plants for a home garden. Growers are taking a chance with such plants as they are often infected with the wilt disease.

USE OF RESISTANT AND EARLY VARIETIES.

The selection of varieties to be used for planting depends upon a number of things, such as soil, rainfall and humidity; the severity of diseases other than wilt; the severity of the wilt disease in the neighborhood and the presence or absence of the wilt disease in the fields to be planted. In sections where the wilt disease is very severe, considerable reliance should be placed on the wilt resistant varieties and in some sections, on the early varieties. In the lower coast region of Louisiana, where the these are very satisfactory varieties, as they will usually produce a Pink are very subject to a leaf disease and fruit rot known as the early blight or nailhead rust, and consequently, these varieties are not very satisfactory. Away from the coast, however, these are very satisfactory varieties, as they will usually produce a part of a crop even in wilt infested soil, if they are started early and are healthy when transplanted.

Until the season of 1919, seed of only two resistant varieties could be purchased from seedsmen, these being the Globe and the Duke of York. The Duke of York, while quite resistant, is a very unsatisfactory tomato, at least under Louisiana conditions, and has not become popular. The Globe is a much better tomato but it is rather late, and usually is a ligh yielder. This tomato, however, has become popular in some sections of the South, especially in Florida and southern Louisiana where the early blight injures the early varieties. In 1919, the Norton and Marvel varieties were placed on the market by at least one seedsman, and it is probable that other satisfactory varieties will be placed on a commercial basis in the near future.

With a proper system of rotation and with resistant plants, grown in disease free seed beds, and consequently healthy when set in the field, a grower should be able to obtain a satisfactory crop, even in the worst wilt section of the state.

SUMMARY.

The principal points brought out in this bulletin are briefly summarized:

(1). The tomato wilt disease is found in the warmer regions throughout the world. In the United States, it is common as far north as the Ohio Valley and New Jersey.

(2). The fungus which causes the disease *Fusarium lycopersici* attacks the roots of the plants and grows up through the fibrovascular bundles into the stems, leaves and sometimes the fruits. The fibrovascular system is changed to a dark color; the plants finally die.

(3). The work on a disease of this kind is made easier by growing the plants in reinoculated sterilized soil in the greenhouse. Under such conditions, the young plants become affected very soon after they come through the ground.

(4). While the disease is not usually carried on the seed, the spores of the fungus will live on the seed from the time it is saved until planting time, the following spring.

(5). The length of time the fungus will live in the soil is not known, but it decreases from year to year, so that by the third year there is not usually enough in the soil to produce a heavy infection.

(6). The wilt develops best in the lighter, richer soils. It is of little importance in the heavy, alluvial soils.

(7). Lime added to the soil in large amounts, such as ten tons to the acre, hinders the development of the wilt. The disease can also be checked in the seed beds to some extent with formadlehyde and corrosive sublimate. Other substances tested, include wood ashes, sulfur, sulfuric acid, kainit, and copper sulfate.

(8). Different cultures of the fungus show some slight variations in regard to virulence, but no evidence has been obtained that would indicate that there may be different strains attacking different varieties.

(9). The fungus grows best at a temperature around 29°C. Infection also, takes place quicker and the disease develops in the plants more rapidly if the soil is kept around that temperature. If the temperature remains constantly considerably below this, very little infection results.

(10). In the field, the normal development of the disease takes place after the soil has reached the optimum temperature.

(11). Strains or varieties of tomatoes showing resistance or tolerance to the disease have been selected at the Louisiana Station and elsewhere. All of these selections become infected with the wilt disease but the plants do not die as quickly as susceptible plants.

(12). Of the commercial tomatoes, varieties like the Stone, Bonny Best and a number of others are very susceptible, and usually produce but light crops on infested soil.

(13). Early varieties like the Earliana and June Pink usually develop so rapidly that they will produce a part of a crop if the plants are healthy when set in the field.

(14). Control measures consist of rotation, seed bed sanitation, and the use of resistant and early varieties.

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The Prevention of Sugar Deterioration

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The Prevention of Sugar Deterioration*

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The phenomenon of sugar deterioration has been the subject of considerable investigation which has been discussed in detail in previous publications (6 and 7). Briefly summarizing these results it may be stated that a comprehensive survey was made of the molds occurring in cane sugars of all descriptions and a further study of their capacity to deteriorate sugar. It has been shown that mold spores contain invertase in sufficient quantity to cause deterioration; and the influence of the number of mico-organisms and concentration of medium have been studied in detail. Finally it was possible to prepare a chart whereby the keeping quality of sugar may be predicted. This is based on a preliminary chemical and bacteriological analysis involving polarization, moisture content, and a number of microörganisms per gm. A study of the microörganisms in each stage of the manufacturing process of sugar has shown that the massecuite as it is dropped from the vacuum pan is sterile and that reinfection takes places from this point on, becoming especially heavy at the centrifugal. Having determined the critical points of infection, it was necessary to develop some method for its control by the elimination of the causative organisms, thus preventing the deterioration of sugar.

PART I.

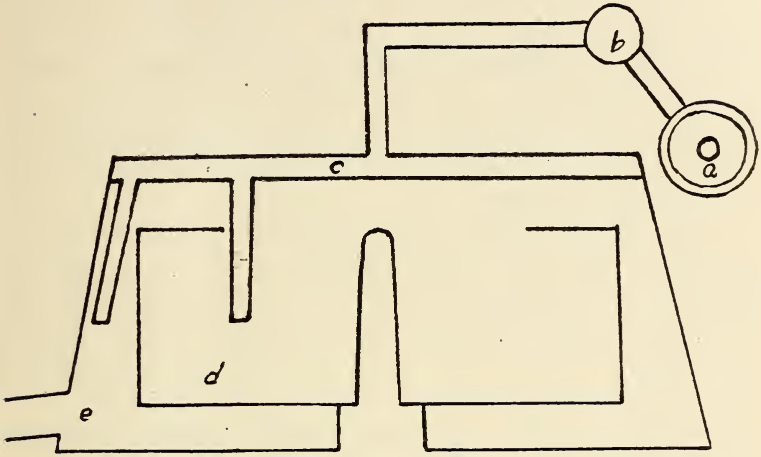
THE PREVENTION OF SUGAR DETERIORATION BY THE USE OF SUPERHEATED STEAM IN CENTRIFUGALS.

Shorey[9] and others have suggested the use of superheated steam in the centrifugals, but so far as we have been able to ascertain no controlled experiments have been conducted to test out the efficiency of such an agent. Unfortunately, it was not possible to arrange for an equipment in our sugar house and mill which would permit of such a study and it was thanks to Assistant Director W. G. Taggart, who devised an apparatus to be used in the laboratory centrifugal, that the following experiment was made possible.

The centrifugal used was an 11-inch, 1915 model, No. 2, made by the International Instrument Company of Cambridge, Mass. The basket had a diameter of 11 inches and a depth of 3½ inches. A larger concave jacket 15¼ inches in diameter and 6½ inches deep caught the molasses. The device used for superheated steam was simple in construction, consisting of a ½-inch intake pipe with two arms (⅜ inch diameter), one inside the basket, stopping 1½ inches from the bottom, the other between the basket and the trough. These were made of copper, sealed off at the lower end, and had a slit in the side facing the surface of the sugar. The device was securely attached by means of screws to the outside trough. An autoclave was used as a source for steam, the outlet pipe being connected by a nipple and thick rubber tubing with a 10-inch superheater (or heating spiral such as used with an Abbé refractometer), which in turn was connected with rubber tubing to the device in the centrifugal through a hole in the cover, the latter being kept closed during the course of the experiment. Figure I is a diagrammatic illustration of the apparatus used.

FIGURE I.

Diagram of Device for Using Superheated Steam in the Laboratory Centrifugal.



Legend:

a—Autoclave
b—Superheater
c—Intake pipe with arms for delivering steam on inside and outside of basket.
d—Basket
e—Jacket.

Confectioners crystals, which are large in size, were sterilized and coated with a blackstrap molasses which was heavily inoculated with microörganisms, such as *Aspergillus* Sydowi Bainier, *Aspergillus niger, Penicillium expansum,* B. *vulgatus,* B. *megatherium,* B. *mesentericus,* and all the bacterial colonies developing from 150 plates poured from Cuban raw sugar. A massecuite of medium density was prepared and the centrifugal steamed out after receiving a swabbing with alcohol containing carbolic acid.

The procedure was as follows: The autoclave was run up to 22 lbs. pressure or a temperature of 263°F. The massecuite was heated to 104°F. (40°C.) for about ten minutes and poured into the centrifugal basket until it formed a layer ¾ of an inch deep. The superheater was started with a Bunsen burner (asbestos being used to protect the rubber tubing), to get it well heated before the steam was added; then the centrifugal was put in operation (attaining a maximum of 3,000 revolutions per minute), and the steam turned on for three minutes.

Upon stopping the steam and centrifugal the temperature of the sugar was 155°F. (68°C.). Naturally, the sugar cooled very rapidly and doubtless the heat attained while the superheated steam was being applied was considerably in excess of this figure. The sugar was washed as white, if not whiter, than with a jet of water such as ordinarily used. Samples of the sugar and the molasses coming from it were taken in sterile containers for bacteriological analysis.

The same procedure was repeated with a 1½-inch layer of massecuite previously heated to 136°F. (58°C.) for about five minutes and about 122°F. (50°C.) for ten minutes more. In this case the steam treatment was interrupted, due to a bend in the tubing which blew off one of the connections. At the end of the treatment the temperature of the sugar was 158°F. (70°C.)

The samples taken above were plated out in three dilutions on Kopeloff's agar[6], incubated at 30°C., and read after three and seven days. The data are presented in Table I, in which are recorded the closely agreeing averages of quadruplicate determinations of each of the three dilutions.

TABLE 1.

The Effect of Superheated Steam in the Centrifugal on the Number of Microorganisms in Sugar.

TREATMENT	Bacteria per gm.	Holds per gm.	Per Cent Reductions	
			Bacteria	Molds
Untreated, 40°C.	1,500,000	550		
Steamed	8,000	10	99.47	98.28
Molasses —	235,000	275	84.34	50.00
Untreated, 58°C.	200,000	110		
Steamed*	14,000	10	93.00	90.91

*Steam treatment interrupted.

It will readily be seen that in the first instance the untreated massecuite had 1,500,000 bacteria and 550 molds per gm., while the treatment with superheated steam resulted in reducing the content to 8,000 bacteria and 10 moulds per gm., which is a diminution of 99.47 per cent of the bacteria and 98.28 per cent of the molds respectively.

This means an efficiency in the decimation of the microorganisms that is remarkable and the significance of which will be discussed in detail presently.

The molasses from this sugar had 235,000 bacteria and 275 molds per gm., a reduction in 84.34 per cent of the bacteria and 50 per cent of the molds.

This is again proof of the sterilizing effect of superheated steam, since it may be inferred that the heat attained for the short time necessary to wash the molasses from the sugar was sufficient to kill more than three-fourths of the bacteria and one half the molds. Furthermore, this is of practical value from the standpoint of the keeping quality of the molasses. We have previously referred to unsanitary conditions under which most molasses is kept and that frequently we have observed tanks literally covered with a mat of mold mycelium. It is logical to suppose that where the original mass infection may be so materially reduced, the keeping quality of such a product may be greatly enhanced. Moreover, we have here an advantageous substitute for wash water which is frequently of questionable character and often responsible for a heavy inoculation with microörganisms.

Moreover, these data indicate that by far the larger proportion of microörganisms contained in the massecuite leave the centrifugal in the wash. Therefore, when it is the practice to separate the molasses and the wash, a less contaminated molasses is procured which undoubtedly improves its keeping quality.

In this connection a digression may be permitted which may be worthy of trial—namely, where molasses is not fermented and it is desired to keep it for some time, we would suggest the use of a thin layer of oil on the surface, which would prevent a mass infection at that vulnerable point and which could be easily removed. The oil in this way need not affect either the quality, odor, or taste of the molasses. On the other hand, where mold growth already covers the surface, it might be advisable to spray with toluene, which is cheap enough to be economical, germicidal enough to kill the molds, and volatile enough to be removed within a few days by exposure to the air. Since the pressure of time does not permit of the opportunity of developing these suggestions in the sugar mill, they are merely advanced for what they may be worth.

Returning to the latter half of Table I, it will be seen that where the massecuite was heated to 122°F. (50°C.) the untreated sample contains only about one-eighth the number of bacteria and one-fifth the number of molds present in the massecuite heated to 104°F. (40°C.). This means that a partial sterilization has already been effected. The treatment with superheated steam was interrupted and the final results show that 93 per cent of the bacteria and 91 per cent of the molds were eliminated. It was to be expected that these figures would be somewhat below those obtained in the first instance, since the partial sterilization just referred to probably eliminated the least resistant organisms and left a flora relatively more resistant than the one originally present. The interruption of the steam treatment must have been responsible for some loss in efficiency. Finally, the difference may be ascribed to the fact that the layer of sugar in this instance was twice as thick as that used in the first instance. It is to be expected that four important factors would be operating in such an experiment—namely, (1) temperature of steam, (2) duration of application, (3) thickness of layer of massecuite, (4) speed of centrifugal.

From the data set forth it is evident that the use of superheated steam under the conditions of the experiment was instrumental in almost entirely eliminating the microörganisms present. The important consideration being that this was accomplished without increasing the moisture content of the sugar perceptibly, as in washing with water. As a matter of fact, under mill conditions it might be anticipated that even better results might be obtained where higher temperatures might be so readily available. The procedure has the merits of (1) simplicity in construction and operation; (2) economy in equipment, installation and operation; (3) efficiency under all conditions; (4) yielding a cleaner wash.

In working out a chart for predicting the keeping quality of sugar it was shown that two factors operated simultaneously—namely, moisture ratio and degree of infection[7]. It is obvious, therefore, that such a striking reduction in mass infection can be effected by the use of superheated steam in the centrifugals that the keeping quality may be greatly enhanced, even where the moisture is somewhat more than it should be. For example, a sugar having a moisture ratio of .08 will deteriorate when 10,000-100,000 mold spores per gm. are present. A reduction of 98 per cent, however, bringing the content down to about 1,000 spores per gm. would make this sugar safe even though the moisture ratio increased to as much as .14-.16.

Thus it will be said that in the investigations on sugar deterioration carried forward in this laboratory, the study of the microorganisms and their activities, which made possible the prediction of the keeping quality of sugars, has found its logical completion in the development of an adequate means for eliminating the microörganisms and consequently preventing sugar deterioration. However, it must be emphasized again that the sugar must be properly handled under sanitary conditions with a minimum possibility of absorbing moisture in order to insure its safekeeping, since, under optimum conditions, the microörganisms soon propagate rapidly enough to become detrimental.

SUMMARY.

1. A method has been developed for employing superheated steam in laboratory centrifugals.
2. By means of this treatment the bacterial content of sugar has been reduced 93-99.5 per cent, and the number of mold spores has been reduced 92-98 per cent. The microörganisms in molasses are reduced similarly to a lower extent.
3. This elimination of microörganisms improves the keeping quality of the sugar as well as the molasses.
4. The practice of separating molasses and wash results, with superheated steam treatment in a considerable reduction of microörganisms in molasses, which improves its keeping quality.
5. The method is simple, economical and efficient.

PART II.

THE DETERIORATION OF CUBAN RAW SUGARS IN STORAGE.

Ordinarily few precautions are observed in attempting to safeguard against the deterioration of sugar. The more progressive sugar factors are aware of the importance of the moisture ratio in sugars and attempt to reduce this to as low a point as is consistent with sugar house practice. As has been pointed out, this is one of the two primary factors which must be considered. However, there has been little regard for the other factor of equal importance which must be considered simultaneously—namely, the degree of infection. To emphasize the practical aspect of this conception, the following experiment was undertaken.

Many investigators have advanced evidence which proves that the loss in sucrose content which manufactured sugar undergoes on storage is due in a large measure to microbiological activities. While much valuable data may be found giving the analyses of sugars which have undergone deterioration, or those artificially inoculated for that purpose, there has not come to our notice any study based on the concomitant bacteriological and chemical analyses of sugar when stored under normal conditions and which might be regarded as representative of large quantities of similarly stored sugar.

Two 320-pound bags of each of three different "marks" of Cuban raw sugar representing an aggregate of approximately 5,586 tons of sugar were analyzed chemically and bacteriologically at the beginning of the storage period, and again in an identical manner at the end of one and five and one-half months respectively. Each bag was sampled as follows: A "long" trier was run in three places through the middle for the entire length of the bag. Two samples were drawn from each hole, and then all mixed thoroughly on a sterile glazed paper, the composite being taken as representative of the contents of the middle of the bag. The usual precautions in bacteriological technique against contamination of trier, mixing, etc., were observed by the use of alcohol. The bag was then skinned in two places—that is, the sugar at the surface, just inside the bag, was taken. Three samples were taken from each of these two holes, and after being thoroughly mixed, as indicated above, were considered representative of the surface contents of the bag. All the holes thus made were immediately sewn up, except the hole always made by the official sampler with a short trier. These samples were analyzed chemically at once and a portion collected for bacteriological analysis in sterile containers. These were plated on Kopeloff's agar[6] in three dilutions. The averages given in the succeeding tables represent triplicate determinations of each dilution.

The bags were piled in two rows of three each (the lowest ones resting on the floor) and two burlap sacks thrown over the sides to approximate as normal storage conditions as possible. Analyses were made at the end of one, four and one-quarter and five and one-half months respectively.

A second series of bags were similarly obtained and analyzed the same way. These bags, however, represented only two marks, but were triplicate bags, one mark being taken from the top of the vessel where the bags had been heated, the other mark taken from the bottom of the vessel, two bags having been "stained" and another not "stained."

The chemical and bacteriological analyses of all samples are presented in Table 2 and summarized in Tables 5 and 6; Table 3

TABLE 2.
Chemical and Bacteriological Analyses of Cuban Raw Sugars in Storage.

Name	Description	No.	Part of Bag	Date	Pol.	Loss in Pol.	Moisture %	R. S. %	Gain in R. S. %	Ash	Factor of Safety.	No. Mic. Per Gm.	Molds %
B	Light	1	Mid.	5/7	96.4	....	1.38	.62	....	.54	.38	550	18
				6/10	97.0	....	1.07	.63	.01	...	.36	200,000	*
				10/2	88.0	8.4	2.65	4.19	3.57	...	.22	12,500	*
		1S	Sur.	5/7	97.0	....	1.47	.62	...	...	.49	463	14
				6/10	96.8	0.2	1.15	.76	.06	...	.36	2,500	*
				10/21	94.2	2.8	1.66	1.51	.89	...	.29	11,500	5
B	Dark	2	Mid.	5/7	93.8	....	1.88	1.26	....	.80	.30	480	6
				6/10	94.0	....	1.75	1.26	....	...	.29	19,000	*
				10/21	93.9	—	1.80	1.12	—	...	.30	4,250	7
		2S	Sur.	5/7	93.5	....	2.10	1.49	....	...	.32	1,034	2
				6/10	94.0	....	1.76	1.41	....	...	.30	23,000	*
				10/21	92.5	1.0	2.54	1.84	.35	...	.34	17,250	2
M	Wet	3	Mid.	5/7	93.8	....	1.61	2.24	....	.45	.26	77,000	*
				6/10	93.0	0.8	1.44	2.84	.60	...	21	19,000	*
				10/21	84.5	9.3	3.03	6.25	4.01	...	.20	17,500	15
		3S	Sur.	5/7	96.9	....	1.10	0.78	....	...	.36	4,305	*
				6/10	92.5	4.4	4.03	1.55	.77	...	.54	3,000	*
				10/21	88.0	8.9	2.92	5.69	4.91	...	.24	7,250	4
	Av.	4	Mid.	5/7	95.0	....	1.34	2.21	....	.45	.27	38,035	*
				6/10	94.4	0.6	1.08	2.53	.32	...	.20	50,000	*
				10/21	87.3	7.7	2.94	5.95	3.74	...	.23	33,500	*
		4S	Sur.	5/7	96.9	....	.94	.80	....	...	.30	4,018	1
				6/10	95.3	1.6	1.20	2.29	1.49	...	.26	55,000	*
				10/21	91.3	5.6	2.25	3.76	2.96	...	.26	8,500	*
U	Wet	5	Mid.	5/7	95.3	....	1.71	.75	....	.63	.36	1,547	3
				6/10	95.0	0.33	1.31	1.23	.48	...	.26	1,700	*
				10/21	94.5	0.8	1.73	1.59	.84	...	.31	22,000	*
		5S	Sur.	5/7	95.8	....	1.45	1.22	....	...	.35	251	12
				6/10	95.9	....	.90	1.14	....	...	.22	800	*
				10/21	90.5	5.3	2.81	3.71	1.49	...	.30	11,500	*
	Av.	6	Mid.	5/7	96.0	....	1.60	.64	....	.55	.40	508	16
				6/10	96.0	....	1.20	1.02	.58	...	.30	20,500	*
				10/21	91.1	4.9	2.21	4.13	3.4	...	.25	16,000	1
		6S	Sur.	5/7	96.8	....	1.16	.61	....	...	.36	1,040	3
				6/10	97.0	....	.85	.92	.31	...	.28	870	*
				10/21	89.8	7.0	3.00	5.55	4.94	...	.30	8,000	*
G	Heated in top of vessel	7	Mid.	6/13	96.1	....	1.63	.56	....	...	.42	135	*
				10/21	93.8	2.3	1.85	2.53	1.97	...	.30	350,000	*
		7S	Sur.	6/13	96.8	....	1.06	.65	....	...	.33	275	*
				10/21	90.3	6.5	2.75	4.19	3.54	...	.28	80,000	*
		8	Mid.	6/13	96.2	....	1.74	.58	....	...	.46	285	*
				10/21	93.5	2.7	1.92	2.53	1.95	...	.30	6,000	*
		8S	Sur.	6/13	95.9	....	1.24	1.23	....	...	.30	170	*
				10/21	94.5	1.4	2.20	1.44	.21	...	.40	250,000	*
		9	Mid.	6/13	96.7	....	1.15	.67	....	...	.35	90	*
				10/21	93.2	3.5	1.88	2.53	1.86	...	.27	5,500	*
		9S	Sur.	6/13	96.9	....	.80	.97	....	...	.26	190	*
				10/21	88.5	8.4	3.40	6.25	5.28	...	.30	8,500	*
C	Stained in bottom of vessel	10	Mid.	6/13	94.8	....	1.67	1.43	....	...	.32	2,250	*
				10/21	94.5	0.3	1.60	1.70	.27	...	.29	25,000	*
		10S	Sur.	6/13	94.4	....	1.62	1.22	....	...	.29	80,000	*
				10/21	94.0	0.4	2.71	2.08	.86	...	45	135,000	*
		11	Mid.	6/13	95.8	....	1.23	1.46	....	...	.30	80	*
				10/21	89.8	6.0	2.73	4.38	2.92	...	.27	75,000	*
		11S	Sur.	6/13	95.6	....	1.00	1.02	....	...	.23	550	*
	Not stained in bottom of vessel			10/21	93.6	3.0	2.35	2.48	1.46	...	.37	95,000	*
		12	Mid.	6/13	96.6	....	1.21	.66	....	...	.28	5,000	*
				10/21	94.0	2.6	1.89	1.96	1.30	...	.32	75,500	*
		12S	Sur.	6/13	96.6	....	.95	.87	....	...	.22	40,000	*
				10/21	94.0	2.6	2.07	1.70	.83	...	.35	135,000	*

*Negligible amount.
Mid.—Middle.
Sur.—Surface.

TABLE 3.

Temperature and Relative Humidities at New Orleans, La., May to October, 1919.

MONTH	Relative Humidity	Temperature °F		Mean
		Maximum	Minimum	
May	75	85.04	64.00	74.52
June	77	88.00	69.00	78.10
July	77	91.00	71.80	81.40
August	79	91.50	72.90	82.22
September	67	88.10	68.10	78.10
October	76	90.00	67.00	88.50
Average	75	88.90	68.60	80.47

TABLE 4

Differences Between Successive Samplings.

Name	Description	Part	Date	Pol.	Moist.	R. S.	F. S.	Mic.	Molds
B	Light	Middle	6/10	+	—	+	—	+	—
			10/21	—	+	+	—	—	+
		Surf.	6/10	—	—	+	—	+	—
			10/21	—	+	+	—	+	+
	Dark	Middle	6/10	(+)	—	+	(—)	+	—
			10/21	(—)	+	—	(+)	—	+
		Surf.	6/10	+	—	—	—	+	—
			10/21	—	+	+	+	—	+
M	Wet	Middle	6/10	—	—	+	—	—	
			10/21	—	+	+	—	—	+
		Surf.	6/10	—	+	+	+	—	
			10/21	—	—	+	—	+	+
	Av.	Middle	6/10	—	—	+	—		
			10/21	—	+	+	+	+	—
		Surf.	6/10	—	+	+	—	—	
			10/21	—	+	+			
U	Wet	Middle	6/10	—	—	+	—	+	—
			10/21	—	+	+	+	+	
		Surf.	6/10	—	—	—	—	+	—
			10/21	—	+	+	+	+	
	Av.	Middle	6/10		—	+	—	+	—
			10/21	—	+	+	—	—	+
		Surf.	6/10	+	—	+	—	—	—
			10/21	—	+	+	+	+	
G	Heated	Middle	10/21	—	+	+	—	+	
		Surf.	10/21	—	+	+	—	+	
		Middle	10/21	—	+	+	—	+	
		Surf.	10/21	—	+	+	+	+	
		Middle	10/21	—	+	+	—	+	
		Surf.	10/21	—	+	+	+	+	
C	Heated	Middle	10/21	—	(—)	+	—	+	
		Surf.	10/21	—	+	+	+	+	
		Middle	10/21	—	+	+	—	+	
		Surf.	10/21	—	+	+	+	+	
		Middle	10/21	—	+	+	+	+	
		Surf.	10/21	—	+	+	+	+	
	Moist	Middle	10/21	—	+	+	+	+	
		Surf.	10/21	—	+	+	+	+	

+ Increase over previous sampling.
— No increase over previous sampling.
( ) Questionable.

gives the conditions of humidity and temperature which obtained through this incubation period.

Certain important generalizations may be deduced from the above data; among them is the fact that there is a loss in polarization in all samples under consideration in the present experiment held for five and one-half months. There is also a loss in polarization in practically all samples held one month or longer and again in moisture content. The loss in polarization in each instance has generally been accompanied by a gain in reducing sugars, indicating that the loss is due to true inversion due to microbiological agencies. It will be remembered that Browne[2] has pointed out that "The average Cuban sugar of 96 per cent sucrose would deteriorate if stored in New York for one year to 95 and if stored in Cuba to 94 per cent sucrose," which, calculated at 1916 prices, would amount to $1,150,929.

This large figure would have to be increased at current prices and production. From the foregoing tables it will be seen in one case that there has been a loss of 9.3 per cent, while there are three instances of a loss of more than 8.0 per cent. The economic importance of such data is too obvious to require amplification.

The total numbers of microörganisms responsible for this deterioration must needs vary considerably because of the difficulties in such an experiment of controlling the many variable factors which might have an influence on the microörganisms. However, it may be observed that in all bags heated in the top of the vessel during transit, or held in the bottom of the vessel, there was a decided increase in the number of microörganisms. As a rule, the per cent of molds increased during the longer storage period, but often did not do so in one month. In general, there were more microörganisms in the middle than at the surface of the bag, as might readily be expected, since the microorganisms at the periphery were more subject to a drying-out process. A correlation between numbers of microörganisms and deterioration was discernible where there was a heavy initial infection or a noteworthy rapid increase in the number of microorganisms. The factor of safety or moisture ratio, which is calculated by the formula $\text{M.R.} = \frac{\text{Moisture}}{100 - \text{Polarization}}$, is in most instances over .35, in six of the instances .30 or more, in four of the instances over .27, and in the remaining four instances .22 or over. From the evidence advanced by other investigators the general concensus of opinion seems to place the limit for the factory of safety at about .30. From the standpoint of mold infection it was found that even sugar with a lower factor of safety was unsafe, when sufficiently infected, and this would likewise seem to be the case where other microörganisms were concerned, as in the above instances, which represent about one-third of the samples under observation.

From the work done with molds it was concluded that with moisture ratios over .20, only 100 mold spores per gm. were sufficient to cause deterioration. Since bacteria are, as a rule, somewhat smaller than mold spores it might be expected that a somewhat larger number of bacteria would be required to produce the same degree of deterioration. Therefore if there were more than 100 bacteria at moisture ratios or factors of safety greater than .20, deterioration might be expected. That such is actually the case may be seen from Table 5. For here we find

TABLE 5.

Summary Showing Magnitude of Deterioration.

No.	Name	Description	Part of Bag	Gain R. S. %	Loss in Pol.	Factor of Safety	No. Micro. Per Gm.	Deterioration predicted from F. S.	Deterioration not predicted from F. S. but from No. of Microorg.
9S	G		Surf.	5.28	8.4	.26	190	—	+
6S	U	Av.	Surf.	4.94	7.0	.36	1,040	+	
3S	M	Wet	Surf.	4.91	8.9	.36	4,305	+	
3	M	Wet	Mid.	4.01	9.3	.26	77,000	—	+
4	M	Av.	Mid.	3.74	7.7	.27	38,035	—	+
1	B	Light	Mid.	3.57	8.4	.38	550	+	
7S	G		Surf.	3.54	6.5	.28	80,000	—	+
6	U	Av.	Mid.	3.49	4.9	.40	508	+	
4S	M	Av.	Surf.	2.96	5.6	.30	4,018	+	
11	C	St.	Mid.	2.92	6.0	.30	80	+	
7	G		Mid.	1.97	2.3	.42	135	+	
8	G		Mid.	1.95	2.7	.45	285	+	
9	G		Mid.	1.86	3.5	.35	90	+	
5S	U	Wet	Surf.	1.49	5.3	.35	251	+	
11S	C	St.	Surf.	1.46	3.0	.23	550	—	+
12	C	Unst.	Mid.	1.30	2.6	.28	5,000	—	+
1S	B	Light	Surf.	0.89	2.8	.49	463	+	
10S	C	St.	Surf.	0.86	0.4	.29	75,000	—	+
5	U	Wet	Mid.	0.84	0.8	.36	1,547	+	
12S	C	Unst.	Surf.	0.83	2.6	.22	40,000	—	+
2S	B	Dark	Surf.	0.35	1.0	.32	1,034	+	
10	C	St.	Mid.	0.27	0.3	.32	2,250	+	
8S	G		Mid.	0.21	1.4	.30	170	+	
2	B	Dark	Mid.	—	—	.30	430	+	

that deterioration occurs with factors of safety from .22 to .29, and the microörganisms responsible vary in number from 190 to

80,000 per gm. It is especially significant that the five largest numbers of microörganisms caused deterioration at factors of safety below .30. Browne[2] has shown that the explanation for this phenomenon is that the factor of safety becomes lower and consequently unreliable where deterioration is already in progress. This leads to an important commercial application—namely, next to eliminating deterioration, it is of importance to predict the keeping quality of a sugar. It has been worked out empirically and scientifically that deterioration may be predicted at .26 in sugars with a factor of safety greater than .30, and this is used as the basis for the next to last column of Table 5. In the final column, however, is included a prediction of deterioration based not on the factor of safety (for this is below .30), but on the number of microörganisms per gm., *i. e.,* with factors of safety above .20, upwards of 100 microörganisms per gm. would be expected to cause deterioration. While it is not possible to predict deterioration from the total number of microörganisms as confidently as in the case of mold infection, nevertheless the parallel seems very striking and further experiments now in progress will form the basis for verification.

TABLE 6.
Sugars Ranked According to Deterioration.

Order	Name	Most Deterioration by bag	Most Deterioration in bag	Least Deterioration by bag	Least Deterioration in bag
1	M	Wet	Surface	Average	Middle
2	G	—	Surface	—	Middle
3	U	Average	Surface	Wet	Surface
4	B	Light	Middle	Dark	Surface
5	C	Stained	Surface Middle	Unstained	Middle Surface

In Table 6 the sugars under investigation have been ranked in order of greatest deterioration. This ranking was arrived at by evaluation from the complete list in Table 5 and making the proper averages. In this way it is possible to tell at a glance that the greatest deterioration occurred in the M sugar, followed in order by G, U, B, and C. Similarly it is evident which of the duplicate bags (according to description) showed the most deterioration, and finally which part of that bag deteriorated to the greatest extent. Because of the variety of sugars under consideration and the variation in composition, it is difficult to make many generalizations. However, it is interesting to note that the sugar which did not have a particularly high factor of safety and which deteriorated to the greatest extent contained the largest number of microörganisms per gm. (as may be seen from Table 5). A similar phenomenon is to be noted in the C sugar. On the other hand, G, which was next in order of deterioration, had a comparatively high factor of safety and rather small number of microörganisms per gm. This would indicate again that deterioration is a resultant of these two variable factors. This fact to be observed in the G sugar is repeated in the case of the U and B sugars, which have relatively high factors of safety and not very high counts of microörganisms.

Considering the bag of each mark which showed the greatest deterioration, it is evident that those described as wet, stained, and light showed the greatest deterioration, as might be expected. The exception seems to be the U "average," which actually had a higher factor of safety than the so-called "wet" bag, and consequently might be expected to show greater deterioration, as was the case. When attention is turned to the part of each bag showing greatest deterioration, it is found that in general that in the bags of each mark which had deteriorated to the greatest extent the surface shows most deterioration, while in the bags which have deteriorated least the middle of the bag seems to have been most affected. These results, as well as the fact that the factor of safety was found to decrease in every sample examined at the end of the incubation period, would appear to corroborate the very interesting report on deterioration of sugar in storage by Blake[1], as well as the investigations of Browne[2], Owen[8], and others already referred to.

In general it was found that the deterioration was proportionally greater over the longer incubation period than at the end of one month, and this despite the fact that the total number of microörganisms per gm. increased disproportionately the first month. In fact, it would appear that rapid deterioration followed a rapid increase in the number of microörganisms.

The foregoing investigation, which is concerned with the chemical and bacteriological analyses of Cuban raw sugars under normal conditions of storage, has served to bring out rather clearly the intimate correlation between the composition of a sugar and its microbiological content as influencing deterioration. In this way it becomes possible to modify the so-called "factor of safety rule" from the standpoint of microbiological infection and arrive at a satisfactory basis for predicting the keeping quality of sugar.

SUMMARY.

1. From the results indicated below a correlation between the number of microörganisms and the moisture ratio is indicated which appears to make it possible to predict the keeping quality of a sugar by a preliminary bacteriological and chemical analysis.
2. Cuban raw sugars (with moisture ratios varying from .22 to .49) were stored under normal conditions in a large warehouse for five and one-half months and analyzed chemically and bacteriologically. There was a loss in polarization at the end of this period, as well as at the end of one month, which was generally accompanied by a gain in reducing sugars. Likewise, a gain in moisture content and reduction in the factor of safety was noted.
3. There was a decided increase in total number of microörganisms after one month, which could be correlated within certain limitations with deterioration. Where there was a large initial infection, deterioration was rapid. In general, there were more microörganisms in the middle of the bag than at the surface. The per cent of molds increased over the longer incubation period, but often failed to increase in one month.
4. Bags designated as wet, stained, or having sugar light in color deteriorated more rapidly than when drier, unstained, or dark in color. In bags of sugar which are deteriorating rapidly the surface deterioration is greatest, while in less rapid deterioration the middle of the bag seems to undergo greater decomposition.
5. Deterioration was found to be proportionately greater over a longer incubation period than in one month.

PART III

FURTHER STUDIES IN THE DETERIORATION OF A VARIETY OF SUGARS IN STORAGE.

In a study of the deterioration of Cuban raw sugars stored under normal conditions during the summer of 1919 certain conclusions were indicated concerning the correlation between chemical and bacteriological analysis, with special reference to losses in sucrose content*. It was shown that the keeping quality of a sugar depends not only upon the moisture ratio but likewise upon the content of microörganisms, and that any prediction concerning deterioration involves a concomitant consideration of these two factors[7]. In the present investigation of sugars stored in 1920 the technique and procedure were identical with those previously employed, and which have been described elsewhere; the only difference being that in 1920 the position of the bags in any single pile was reversed after four weeks' incubation to obtain uniformity of environment, and the bags were placed on scantling one foot from the floor and protected by a covering of a single layer of sacks.

It was especially designed to have under observation as large a variety of sugars as possible, and from the succeeding data it will be seen that all extremes in polarization, moisture, and number of microörganisms are to be found. This is not only true of the different marks chosen but more significantly of the bags of each mark. As a rule, three bags which varied sufficiently to be considered representative of the mark were chosen, and in some instances, where the variations in a lot were unusual, six bags were taken. It may be mentioned parenthetically that it was planned to sample the bags monthly for six months, but owing to the postponed arrival of sugar it was necessary to delay the initial sampling and thus curtail the number of analyses. In the succeeding tables the names of the marks have been abbreviated to symbols since there has been no intention of subjecting any of the sugars to criticism. All of the sugars came from Cuba with the exception of two marks—M and Ag, from Porto Rico. Seven of the ten marks represent sugars transported by vessel, the remainder having come by railroad via Key West—namely, Am, O, and Pil. The following number of bags of each mark were received, from which the bags under observation were chosen: F, 2,303; Port, 4,694; Cun, 17,000; Agr, 13,500; Cab, 10,000; Am, 2,831; O, 1,406; Pil, 4,060; M, 11,300; Ag, 5,000—totaling 23,070,080 pounds of sugar.

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*Kopeloff, N., and Perkins, H. Z. E., Jour. Ind. Eng. Chem., V. 12, No. 6 (1920), pp. 555-558.

TABLE 7.

Chemical and Bacteriological Analyses of Cuban Raw Sugars in Storage.

Mark	No.	Description	Part of Bag	Date	Pol.	Loss in Pol.	Moisture %	R. S. %	Gain in R. S. %	Ash %	Moisture Ratio	Deterioration Predicted from F. S.	No. Mic. per gm.	Deterioration Predicted from No. Mic.	Molds %
F	1	Vessel	Mid.	3/18	93.2	....	2.90	1.83	....	.30	.43	+	35,000	+	1
				4/15	92.5	0.7	2.80	1.99	.16	....	.37	+	1,650,000	+	*
				5/13	91.4	1.8	3.17	3.13	1.30	....	.37	....	30,000	....	*
			Surf.	3/18	94.2	....	2.31	1.30	....	.30	.40	+	8,000	+	11
				4/15	92.7	1.5	2.34	2.10	.80	....	.32	+	18,000	+	3
				5/13	94.8	....	1.70	1.26	....	....	.33	....	38,000	....	*
F	2		Mid.	3/18	98.2	....	.80	.54	....	.28	.44	+	9,000	+	2
				4/15	97.5	0.7	.96	.59	.05	....	.38	+	170,000	+	*
				5/13	96.9	1.3	1.00	.77	.23	....	.32	....	17,000	....	2
			Surf.	3/18	97.9	....	.75	.58	....	.27	.36	+	2,000	+	10
				4/15	98.4	....	.46	.50	....	....	.29	−	7,600	+	0
				5/13	97.8	0.1	.70	.46	....	....	.31	....	2,100	....	0
F	3		Mid.	3/18	96.4	....	1.70	.63	....	.33	.47	+	134,000	+	0
				4/15	95.8	0.6	1.62	.96	.33	....	.39	+	7,000,000	+	0
				5/13	95.8	0.6	1.67	1.50	.87	....	.40	....	10,000	....	*
			Surf.	3/18	97.0	....	1.20	.66	....	.36	.40	+	156,000	+	0
				4/15	96.6	0.4	1.27	.85	.19	....	.37	+	5,500,000	+	0
				5/13	95.8	1.2	1.50	1.37	.71	....	.36	....	30,000	....	0
Port	1	Vessel	Mid.	3/18	96.5	....	1.08	1.06	....	.39	.31	+	240	+	3
				4/15	96.3	0.2	1.00	1.05	....	....	.27	−	1,500	+	3
				5/13	95.9	0.6	1.30	.93	....	....	.31	....	6,000	....	1
			Surf.	3/18	96.5	....	1.10	1.08	....	.42	.31	+	300	+	0
				4/15	96.5	0	1.02	.98	....	....	.29	−	800	+	0
				5/13	96.3	0.2	1.10	1.04	....	....	.30	....	7,000	....	0
Port	2		Mid.	3/18	96.0	....	1.18	1.16	....	.45	.30	*	6,000	+	....
				4/15	95.9	0.1	1.10	1.09	....	....	.27	−	98	−	2
				5/13	95.8	0.2	1.28	.97	....	....	.30	....	2,250	....	0
			Surf.	3/18	96.2	....	1.16	1.30	....	.42	.30	+	1,150	+	0
				4/15	96.0	0.2	1.10	1.21	....	....	.28	−	150	−	0
				5/13	95.8	0.4	1.19	1.02	....	....	.30	....	8,000	....	*

	3		Mid.	3/18	95.5	....	1.42	1.17	....	.51	.32	+	1,000	+	10
				4/15	95.5	0	1.25	1.09	....	....	.28	−	2,000	+	0
				5/13	95.1	0.4	1.42	1.04	....	....	.30	....	1,800	....	1
			Surf.	3/18	95.4	....	1.42	1.04	....	.55	.31	+	3,100	+	0
				4/15	95.5	....	1.10	1.05	.01	....	.24	−	22,000	+	0
				5/13	95.4	0	1.37	.98	....	....	.30	....	2,150	....	0
Am.	1	R. R.	Mid.	4/1	92.0	....	4.00	1.14	....	.40	.50	+	4,000	+	1
				4/29	90.8	1.2	3.40	2.24	1.10	....	.37	+	120,000	+	1
				5/24	89.5	2.5	3.21	3.44	2.30	....	.31	....	33,000	+	*
			Surf.	4/1	96.0	....	1.01	.81	....	.48	.25	−	2,400	+	17
				4/29	94.8	1.2	1.50	1.62	.81	....	.30	*	4,900	+	0
				5/24	92.5	3.5	2.00	2.74	1.93	....	.27	....	1,900	....	0
	2		Mid.	4/1	95.4	....	1.60	1.47	....	.36	.35	+	19,000	+	0
				4/29	94.2	1.2	1.35	2.34	.87	....	.23	−	90,000	+	0
				5/24	93.0	2.4	1.96	3.01	....	....	.28	....	20,000	....	*
			Surf.	4/1	96.8	....	.94	.76	....	.33	.30	*	850	+	3
				4/29	97.0	....	.90	.91	.15	....	.30	*	14,000	+	0
				5/24	95.7	1.1	1.15	1.54	.78	....	.27	....	1,230	....	13
	3		Mid.	4/1	95.5	....	1.92	.98	....	.36	.43	+	30,000	+	*
				4/29	95.0	0.5	1.30	2.00	1.02	....	.26	−	65,000	+	1
				5/24	94.5	1.0	1.41	2.29	1.31	....	.26	....	2,100	....	3
			Surf.	4/1	96.8	....	.90	.77	....	.33	.29	−	4,000	+	1
				4/29	96.5	0.3	1.00	1.12	.35	....	.29	−	4, 00	+	*
				5/24	95.0	1.8	1.43	2.15	1.38	....	.29	....	400	....	0
	4		Mid.	4/1	95.8	....	1.76	.81	....	.45	.42	+	50,000	+	*
				4/29	94.4	1.4	1.47	1.69	.88	....	.26	−	3,000	+	*
				5/24	93.5	2.3	1.80	2.19	1.38	....	.28	....	750	....	0
			Surf.	4/1	96.2	....	1.12	.91	.05	.45	.30	*	1,500	+	2
				4/29	96.2	0	1.14	.96	....	....	.30	*	280	+	0
				5/24	95.8	0.4	1.10	1.26	.35	....	.26	....	540	....	8
	5		Mid.	4/1	96.8	....	1.32	.69	....	.36	.41	+	7,000	+	*
				4/29	95.2	1.6	1.16	1.92	1.23	....	.24	−	115,000	+	*
				5/24	94.8	2.0	1.33	2.29	1.60	....	.24	....	2,000	....	0
			Surf.	4/1	97.2	....	.90	.70	....	.39	.32	+	340	+	20
				4/29	96.5	0.7	.94	.98	.28	....	.27	−	40,000	+	1
				5/24	97.0	....	.85	.78	....	....	.28	....	1,420	....	5

TABLE 7.—Continued

Chemical and Bacteriological Analyses of Cuban Raw Sugars in Storage.

Mark	No.	De-scrip-tion	Part of Bag	Date	Pol.	Loss in Pol.	Mois-ture %	R. S. %	Gain in R. S. %	Ash %	Mois-ture Ratio	Deteri-oration Pre-dicted from F. S.	No. Mic. per gm.	Deteri-oration Pre-dicted from No. Mic.	Molds %
Am.	6		Mid.	4/1	95.5	....	2.00	1.04	....	.39	.44	+	300,000	+	*
				4/29	95.7	....	1.09	1.71	.67	....	.25	−	120,000	+	*
				5/24	94.3	1.2	1.32	2.26	1.22	....	.23	....	16,000	....	0
			Surf.	4/1	97.0	....	1.24	.73	....	.40	.41	+	300	+	8
				4/29	97.2	....	1.02	.84	.11	....	.36	+	10,000	+	0
				5/24	97.4	....	.80	.76	....	....	.31	....	450	....	0
Cun.	1	Vessel	Mid.	3/22	94.4	....	2.00	.98	....	1.02	.36	+	200	+	0
				4/19	95.4	....	1.75	.76	....	....	.31	+	400	+	0
				5/17	95.8	....	1.71	.47	....	....	.40	....	8,000	....	0
			Surf.	3/22	94.2	....	1.94	1.10	....	....	.34	+	400	+	0
				4/19	94.4	....	2.10	.90	....	....	.46	+	85	−	0
				5/17	94.4	....	2.15	.75	....	....	.38	....	1,100	....	0
	2		Mid.	3 22	94.5	....	1.68	1.19	....	.96	.30	*	1,700	+	1
				4/19	94.1	0.4	2.10	1.24	.05	....	.36	+	110,000	+	0
				5/17	93.5	1.0	2.21	1.33	.14	....	.34	....	120,000	....	0
			Surf.	3/22	94.4	....	1.50	1.24	....	.99	.27	−	1,350	+	0
				4/19	94.5	....	1.85	1.17	....	....	.34	+	2,500	+	0
				5/17	92.0	....	2.00	1.91	.67	....	.23	....	160,000	....	77
	3		Mid.	3/22	95.3	....	1.27	.90	....	.81	.27	−	575	+	78
				4/19	95.3	0	1.52	.81	....	....	.32	+	190	−	17
				5/17	95.0	....	1.70	.83	....	....	.24	....	5,000	....	1
			Surf.	3/22	95.8	....	1.30	.87	....	.80	.31	+	350	+	94
				4/19	95.0	0.8	1.74	.85	....	....	.33	+	190	−	71
				5/17	94.8	....	1.66	.77	....	....	.32	....	480	....	7
	4		Mid.	3/22	97.0	....	1.32	.52	....	.50	.44	+	14,000	+	0
				4/19	95.3	1.7	1.80	1.35	.83	....	.38	+	100,000	+	0
				5/17	93.8	3.2	2.08	2.14	1.58	....	.33	....	19,000	....	*
			Surf.	3/22	97.5	....	1.04	.50	....	.48	.35	+	14,000	+	0
				4/19	96.2	0.8	1.51	.51	.01	....	.40	+	20,000	+	0
				5/17	94.0	3.0	1.81	2.13	1.63	....	.30	....	4,100	....	0

	5		Mid.	3 22	93.8	....	2.21	1.01	....	1.02	.36	+	600	+	25
				4/19	94.0	....	2.33	.92	....	....	.39	+	2 700	+	2
				5/17	94.5	....	2.34	.51	....	....	.43	....	22,000	....	*
			Surf.	3/22	94.2	....	2.10	1.01	....	.98	.36	+	235	+	4
				4/19	94.8	....	1.83	.61	....	....	.35	+	336	+	4
				5/17	94.6	....	1.89	.64	....	....	.35	....	1,000	....	2
	6		Mid.	3/22	96.2	....	1.03	.99	....	.72	.27	−	125	−	0
				4/19	95.4	0.8	1.53	1.01	.02	....	.33	+	250	+	3
				5/17	94.9	1.3	1.70	1.08	.09	....	.33	....	3,000	....	3
			Surf.	3/22	95.5	....	1.20	1.22	....	.78	.27	−	475	+	10
				4/19	94.9	0.6	1.80	1.16	....	....	.35	+	575	+	3
				5/17	95.2	....	1.46	1.06	....	....	.30	....	560	....	8
Agr.	1	Vessel	Mid.	3/30	96.6	....	1.02	.89	....	.48	.30	*	67	−	0
				4/27	96.3	0.3	1.20	.82	....	....	.33	+	1,000	+	25
				5/21	96.0	0.6	1.30	.84	....	....	.33	....	3,000	....	3
			Surf.	3/30	96.7	....	1.00	.83	....	.50	.30	*	125	−	0
				4/27	96.3	0.4	1.16	.88	.05	....	.31	+	350	+	5
				5/21	96.2	0.5	1.04	.80	....	....	.27	....	930	....	0
	2		Mid.	3/30	97.3	....	.94	.57	....	.48	.35	+	120,000	+	0
				4/27	96.8	0.5	1.16	.77	.20	....	.36	+	115,000	+	0
				5/21	96.0	1.3	1.08	1.04	.47	....	.27	....	145,000	....	*
			Surf.	3/30	97.4	....	.94	.58	....	.48	.36	+	18,000	+	0
				4/27	97.5	....	.90	.45	....	....	.36	+	7,500	+	1
				5/21	97.3	0.1	.90	.53	.08	....	.30	....	215	....	0
	3		Mid.	3/30	96.6	....	1.02	.78	....	.54	.30	*	190	−	0
				4/27	96.4	0.2	1.10	.76	....	....	.30	*	1,800	+	*
				5/21	96.3	0.3	1.00	.77	....	....	.33	....	1,150	....	3
			Surf.	3-30	96.5	....	1.07	1.60	....	.59	.30	*	283	+	0
				4/27	96.4	0.1	1.09	.81	....	....	.30	*	300	+	10
				5/21	96.5	....	1.14	.81	....	....	.33	....	220	....	28
Cab.	1	Vessel	Mid.	3/30	94.8	....	1.30	1.45	....	.57	.25	−	300	+	0
				4/27	94.7	0.1	1.50	1.48	.03	....	.28	−	5,750	+	0
				5/21	95.6	....	1.59	.80	....	....	.36	....	225,000	....	*
			Surf.	3/30	94.2	....	1.70	1.60	....	.59	.29	−	250	+	0
				4/27	94.4	....	1.62	1.53	....	....	.29	−	2,200	+	2
				5/21	94.8	....	1.60	1.04	....	....	.31	....	55,000	....	*

TABLE 7.—Continued

Chemical and Bacteriological Analyses of Cuban Raw Sugars in Storage.

Mark	No.	Description	Part of Bag	Date	Pol.	Loss in Pol.	Moisture %	R. S. %	Gain in R. S. %	Ash %	Moisture Ratio	Deterioration Predicted from F. S.	No. Mic. per gm.	Deterioration Predicted from No. Mic.	Molds %
C. b.	2		Mid.	3/30	94.8	....	1.28	1.44	....	.57	.25	−	290	+	0
				4/27	94.8	0	1.45	1.37	....	....	.27	−	165	−	0
				5/21	95.0	....	1.54	1.35	....	....	.31	....	2,000	....	0
			Surf.	3/30	94.7	....	1.40	1.42	0	.52	.26	−	210	+	0
				4/27	94.6	0.1	1.31	1.42	....	....	.24	−	500	+	*
				5/21	94.5	0.2	1.43	1.42	....	....	.26	....	350	....	3
	3		Mid.	3/30	95.2	....	1.80	1.02	....	.61	.38	+	110,000	+	0
				4/27	95.3	....	1.86	.80	....	....	.40	+	....	+	0
				5/21	95.8	....	1.64	.76	....	....	.40	....	52,000	....	0
			Surf.	3/30	94.8	....	1.74	1.35	....	.69	.33	+	1,260	+	1
				4/27	95.4	....	1.30	.87	....	....	.28	−	110,000	+	0
				5/21	95.4	....	1.33	.69	....	....	.29	....	8,000	....	0
O	1	R. R.	Mid.	4/5	96.6	....	.80	.66	....	.54	.24	−	1,700	+	3
				5/3	96.3	0.3	.76	.75	.09	....	.21	−	435	+	0
				5/26	96.4	0.2	.85	.75	.09	....	.24	....	415	....	0
			Surf.	4/5	96.9	....	.59	.75	....	.55	.19	−	335	+	1
				5/3	96.6	0.3	.86	.76	.01	....	.25	−	200	+	17
				5/26	96.9	....	.76	.75	....	....	.21	....	350	....	15
	2		Mid.	4/5	96.9	....	.68	.64	....	.57	.22	−	550	*	10
				5/3	96.6	0.3	.70	.62	.02	....	.21	−	140	−	0
				5/26	96.8	0.1	.60	.64	0	....	.19	....	2,100	....	0
			Surf.	4/5	97.0	....	.60	.70	....	.57	.20	−	275	+	2
				5/3	96.2	0.8	1.00	.68	....	....	.26	−	500	*	*
				5/26	96.5	0.5	.93	.69	....	....	.27	....	4,500	....	*
	3		Mid.	4/5	96.3	....	.95	.75	....	.63	.26	−	700	+	*
				5-3	95.9	0.4	1.00	.77	.02	....	.24	−	1,500	+	0
				5/26	96.1	0.2	.93	.90	.15	....	.24	....	1,100	....	0
			Surf.	4/5	96.5	....	.76	.75	....	.63	.18	−	630	+	5
				5/3	95.9	0.6	1.00	.83	.08	....	.24	−	2,000	+	2
				5/26	96.2	0.3	.90	.87	.12	....	.24	....	1,300	....	0

Pil.	1	R. R.	Mid.	4/5	96.0	....	1.36	.52	....	.42	.34	+	900	+	2
				5/3	95.9	0.1	1.20	.60	.08	....	.29	−	245,000	+	*
				5/26	96.6	....	1.42	.45	....	....	.42	....	53,000	....	1
			Surf.	4/5	95.7	....	1.10	1.05	....	.45	.26	−	340	+	4
				5/3	96.4	....	1.02	.47	....	....	.28	−	240,000	+	*
				5/26	96.7	....	.81	.55	....	....	.25	....	39,000	....	0
	2		Mid.	4/5	95.6	....	1.70	.70	....	.51	.39	+	4,250	+	0
				5:3	95.2	0.4	1.53	.75	.05	....	.32	+	80,000	+	0
				5/26	95.0	0.6	1.20	1.26	.56	....	.24	....	26,000	....	0
			Surf.	4/5	95.8	....	1.30	1.10	....	.54	.31	+	550	*	1
				5/3	95.9	....	1.01	.49	....	....	.25	−	....	....	0
				5/26	95.8	....	1.06	.92	....	....	.25	....	1,850	....	0
	3		Mid.	4 /5	94.4	....	1.88	1.35	....	.42	.34	+	210,000	+	0
				5/3	94.4	0	1.60	1.36	.01	....	.29	−	210,000	+	*
				5/26	94.0	0.4	1.54	1.74	.39	....	.26	....	5,500	....	0
			Surf.	4/5	96.5	....	1.00	.94	....	.40	.29	−	4,750	+	0
				5/3	95.4	1.1	1.70	.78	....	....	.37	+	26,000	+	*
				5/26	95.6	0.9	1.35	1.32	.38	....	.31	....	1,900	....	9
M	1	P. R. Vessel	Mid.	4/5	96.0	....	1.10	.61	....	.70	.28	−	120,000	+	0
				5/3	95.3	0.7	1.30	.77	.16	....	.28	−	75,000	+	*
				5/26	95.4	0.6	1.17	1.20	.59	....	.25	....	130,000	....	*
			Surf.	4/5	96.5	....	.70	.68	....	.66	.20	−	2,300	+	4
				5/3	95.6	0.9	1.29	.72	.04	....	.29	−	Lost	......	0
				5/26	94.8	1.7	1.36	1.34	.62	....	.26	....	360	....	5
	2		Mid.	4/5	96.2	....	.86	1.05	....	.48	.23	−	1,050	+	2
				5/3	95.9	0.3	1.15	1.04	....	....	.28	−	70	−	0
				5/26	96.2	....	1.02	1.04	....	....	.27	....	400	....	0
			Surf.	4/5	97.0	....	.62	.97	....	.50	.27	−	260	+	0
				5:3	96.0	1.0	1.23	.97	....	....	.31	+	370	+	0
				5/26	96.4	0.6	.85	.93	....	....	.23	....	225	....	0
	3		Mid.	4/5	96.3	....	1.16	.48	....	.66	.31	+	350	+	0
				5/3	95.8	0.5	1.27	.83	.35	....	.30	*	100,000	+	*
				5/26	95.2	1.1	1.33	1.53	1.05	....	.28	....	200,000	....	*
			Surf.	4/5	96.3	....	.90	.75	....	.65	.24	−	800,000	+	0
				5/3	96.0	0.3	1.05	.83	.08	....	.26	−	550	+	*
				5/26	96.2	0.1	1.03	.83	.08	....	.27	....	27,000	....	0

TABLE 7.—Continued

Chemical and Bacteriological Analyses of Cuban Raw Sugars in Storage.

Mark	No.	Description	Part of Bag	Date	Pol.	Loss in Pol.	Moisture %	R. S. %	Gain in R. S. %	Ash %	Moisture Ratio	Deterioration Predicted from F. S.	No. Mic. per gm.	Deterioration Predicted from No. Mic.	Molds %
Ag.	1	P. R. Vessel	Mid.	4/5	96.0	....	1.00	1.04	....	.63	.25	—	175	—	0
				5/3	95.5	0.5	1.16	1.08	.04	....	.26	—	250	+	0
				5/26	95.8	0.2	1.04	.90	....	....	.21	....	650	....	8
			Surf.	4/5	96.3	....	.92	1.16	....	.60	.25	—	310	+	0
				5:3	95.6	0.7	1.26	1.01	....	....	.29	—	2,600	+	*
				5/26	95.9	0.4	1.29	1.06	....	....	.31	....	540	....	0
	2		Mid.	4/5	96.6	....	.75	.85	....	.54	.22	—	325	+	0
				5/3	95.6	1.0	1.20	.98	.13	....	.27	—	4,000	+	0
				5/26	96.0	0.6	1.03	.95	.10	....	.26	....	4,500	....	*
			Surf.	4/5	96.8	....	.70	.93	....	.54	.22	—	200	+	30
				5/3	96.3	0.5	1.08	.87	....	....	.29	—	4,500	+	2
				5/26	96.5	0.3	.88	.90	....	....	.25	....	150	....	0
	3		Mid.	4/5	94.4	....	1.35	1.28	....	.80	.24	—	117	—	9
				5/3	94.2	0.2	1.38	1.50	.22	....	.24	—	200	+	5
				5/26	94.2	0.2	1.56	1.47	.19	....	.27	....	2,750	....	1
			Surf.	4/5	94 8	....	1.16	1.41	....	.78	.22	—	230	+	33
				5/3	93.8	1.0	1.63	1.42	.01	....	.31	+	450	+	0
				5/26	94.2	0.6	1.43	1.39	....	....	.25	....	1,100	....	1

NOTE—Pol.—Polarization.
R. S.—Reducing Sugars.
Mic.—Microorganisms.

In Table 7 are presented the chemical and bacteriological analyses of the sugars under normal storage. The moisture ratio or factor of safety has been calculated according to the formula $\text{M.R.}=\frac{\text{Moisture}}{100-\text{polarization}}$, a detailed discussion of which may be found in previous publications (6 and 7). The heading, molds per cent, refers to the per cent of molds based on the total number of microörganisms per gm., as shown in the preceding column.

From the data at hand it will be seen that the sugars vary in initial polarization from 92.0 to 98.2; in moisture, from .75 to 2.90; in per cent reducing sugars, from 0.52 to 1.83; in ash, from 0.28 to 1.02; in moisture ratio, from .18 to .50; in number of microörganisms per gm., from 67 to 134,000; and in per cent molds, from 0 to 94. It is apparent that certain generalizations may be drawn from Table 7—namely, that there is a reduction in polarization in practically all sugars during storage, a fact already established. Furthermore, it is apparent that a decrease in polarization is generally accompanied by an increase in reducing sugars. As might be anticipated, when deterioration sets in during the first four weeks of incubation, it continues through the second four weeks, although it would be difficult to state whether the deterioration is more active in the second period of four weeks than the first. While it is not to be expected that the number of microörganisms present can be correlated with polarization, nevertheless, in general, the greatest number of microorganisms occurs where the moisture ratio is highest, and as a corollary we have observed that the lighter colored sugars, having the highest moisture ratio, deteriorate most rapidly.

TABLE 8.

Temperature and Relative Humidities at New Orleans, La., March, April and May, 1920.

Month	Relative Humidity	Temperature °F		Mean
		Maximum	Minimum	
March	88	84	27	59.40
April	80	87	39	65.85
May	75	92	57	75.75
Average	81	88	41	67.00

TABLE 9.

Differences Between Successive Samplings of Sugars in Normal Storage

Mark	No.	Part of Bag		Date	Pol.	Moist. %	R. S. %	M. R.	Mic.	Molds
F	1	Mid.		4/15	−	−	+	−	+	−
				5/13	−	+	+	*	−	*
			*cp	3/18	−	+	+	−	−	−
		Surf.		4/15	−	+	+	−	+	−
				5/13	+	−	−	+	+	−
			cp	3/18	+	−	−	−	+	−
	2	Mid.		4/15	−	+	+	−	+	−
				5/13	−	+	+	−	−	+
			cp	3/18	−	+	+	−	+	*
		Surf.		4/15	+	−	−	−	+	−
				5/13	−	+	−	+	−	*
			cp	3/18	−	−	−	−	+	*
	3	Mid.		4/15	−	−	+	−	+	*
				5/13	*	+	+	+	−	+
			cp	3/18	−	−	+	−	−	+
		Surf.		4/15	−	+	+	−	+	*
				5/13	−	+	+	−	−	*
			cp	3/18	−	+	+	−	−	*
Port	1	Mid.		4/15	−	−	−	−	+	*
				5/13	−	+	−	+	+	−
			cp	3/18	−	+	−	*	+	−
		Surf.		4/15	*	−	−	−	+	*
				5/13	−	+	+	+	+	*
			cp	3/18	−	*	−	−	+	*
	2	Mid.		4/15	−	−	−	−	−	+
				5/13	−	+	−	+	+	−
			cp	3/18	−	+	−	*	−	*
		Surf.		4/15	−	−	−	−	−	*
				5/13	−	+	−	+	+	+
			cp	3/18	−	+	−	*	+	+
	3	Mid.		4/15	*	−	−	−	+	−
				5/13	−	+	−	+	−	+
			cp	3/18	−	*	−	−	+	−
		Surf.		4/15	+	−	+	−	+	*
				5/13	−	+	−	−	−	*
			cp	3/18	*	−	−	−	−	*
Cun	1	Mid.		4/19	+	−	−	−	*	*
				5/17	+	−	−	+	+	*
			cp	3/22	+	−	−	+	+	*
		Surf.		4/19	+	+	−	+	−	*
				5/17	*	+	−	−	+	*
			cp	3/22	+	+	−	+	+	*
	2	Mid.		4/19	−	+	+	+	+	−
				5/17	−	+	+	−	+	*
			cp	3/22	−	+	+	+	+	−
		Surf.		4/19	+	+	−	+	+	*
				5/17	−	+	+	−	+	*
			cp	3/22	−	+	+	−	+	*
	3	Mid.		4/19	*	+	−	+	−	−
				5/17	−	+	+	+	−	−
			cp	3/22	−	+	−	−	+	−
		Surf.		4/19	−	+	−	+	−	−
				5/17	−	−	−	−	+	−
			cp	3/22	−	+	−	+	+	−
Cun	4	Mid.		4/19	−	+	+	−	+	*
				5/17	−	+	+	−	−	*
			cp	3/22	−	+	+	−	+	+
		Surf.		4/19	−	+	+	+	+	*
				5/17	−	+	+	−	−	*
			cp	3/22	−	+	+	−	−	*
	5	Mid.		4/19	+	+	−	+	+	−
				5/17	+	+	−	+	+	−
			cp	3/22	+	+	−	+	+	−
		Surf.		4/19	+	−	−	−	+	*
				5/17	−	+	+	*	+	−
			cp	3/22	+	−	−	−	+	−

TABLE 9.—Continued

Differences Between Successive Samplings of Sugars in Normal Storage

Mark	No.	Part of Bag	Date	Pol.	Moist. %	R. S. %	M. R	Mic.	Molds.
Cun.	6	Mid.	4/19	−	+	+	+	+	+
			5/17	−	+	+	*	+	*
		cp	3/22	−	+	+	+	+	+
		Surf.	4/19	−	+	−	+	+	−
			5/17	+	−	−	−	−	+
		cp	3/22	−	+	−	+	+	−
Agr.	1	Mid.	4/27	−	+	−	+	+	+
			5/21	−	+	+	*	+	−
		cp	3/30	−	+	−	+	+	+
		Surf.	4/27	−	+	+	+	+	+
			5/21	−	−	−	−	+	−
		cp	3/30	−	+	−	−	+	*
	2	Mid.	4/27	−	+	+	+	−	*
			5/21	−	−	+	−	+	+
		cp	3/30	−	+	+	−	+	+
		Surf.	4/27	+	−	−	*	−	+
			5/21	−	*	+	−	−	−
		cp	3/30	−	−	−	−	−	*
	3	Mid.	4/27	−	+	−	*	+	+
			5/21	−	−	+	+	−	+
		cp	3/30	−	−	−	+	+	+
		Surf.	4/27	−	+	−	*	+	+
			5/21	+	+	*	+	−	+
		cp	3/30	*	+	−	+	−	+
Cab	1	Mid.	4/27	−	+	+	+	+	*
			5/21	+	+	−	+	+	+
		cp	3/30	+	+	−	+	+	+
		Surf.	4/27	+	−	−	*	+	+
			5/21	+	−	−	+	+	−
		cp	3/30	+	−	−	+	+	−
	2	Mid.	4/27	*	+	−	+	−	*
			5/21	+	+	−	+	+	*
		cp	3/30	+	+	−	+	+	*
		Surf.	4/27	−	−	*	−	+	+
			5/21	−	+	−	+	−	+
		cp	3/30	−	+	**	*	+	+
	3	Mid.	4/27	+	+	−	+	*	*
			5/21	+	−	−	*	−	*
		cp	3/30	+	−	−	+	−	*
		Surf.	4/27	+	−	−	+	+	−
			5/21	*	+	−	+	−	*
		cp	3/30	+	−	−	−	+	−
Am.	1	Mid.	4/29	−	−	+	−	+	*
			5/24	−	−	+	−	−	−
		cp	4/1	−	−	+	−	+	−
		Surf.	4/29	−	+	+	+	+	−
			5/24	−	+	+	−	−	*
		cp	4/1	−	+	+	+	−	−
	2	Mid.	4/29	−	−	+	−	+	*
			5/24	−	+	+	+	−	+
		cp	4/1	−	+	+	−	+	+
		Surf.	4/29	+	−	+	*	+	−
			5/24	−	+	+	−	−	+
		cp	4/1	−	+	+	−	+	+
	3	Mid.	4/29	−	−	+	−	+	+
			5/24	−	+	+	*	−	+
		cp	4/1	−	−	+	−	−	+
		Surf.	4/29	−	+	+	*	*	−
			5/24	−	+	+	*	−	−
		cp	4/1	−	+	+	*	−	−
	4	Mid.	4/29	−	−	+	−	−	*
			5/24	−	+	+	+	−	−
		cp	4/1	−	+	+	−	−	−
		Surf.	4/29	*	+	+	*	−	−
			5/24	−	−	+	−	+	+
		cp	4/1	−	−	+	−	−	+

TABLE 9.—Continued

Differences Between Successive Samplings of Sugars in Normal Storage

Mark	No.	Part of Bag	Date	Pol.	Moist. %	R. S. %	M. R.	Mic.	Molds
Am.	5	Mid.	4/29	–	–	+	–	+	*
			5/24	–	+	+	*	–	–
		cp	4/1	–	+	+	–	–	–
		Surf.	4/29	–	+	+	–	+	–
			5/24	+	–	–	+	–	+
		cp	4/1	–	–	+	–	+	–
	6	Mid	4/29	+	–	+	–	–	*
			5/24	–	+	+	–	–	–
		cp	4/1	–	–	+	–	–	–
		Surf.	4/29	+	–	+	–	+	–
			5/24	+	–	–	–	–	*
		cp	4/1	+	–	+	–	+	–
O	1	Mid.	5/3	–	–	+	–	–	–
			5/26	+	+	*	+	–	*
		cp	4/5	–	–	+	*	–	–
		Surf.	5/3	–	+	+	+	–	+
			5/26	+	–	–	–	+	–
		cp	4/5	*	+	*	+	+	+
	2	Mid.	5/3	–	+	–	–	–	–
			5/26	+	–	+	–	+	*
		cp	4/5	–	–	*	–	+	*
		Surf.	5/3	–	+	–	+	+	–
			5/26	+	–	+	+	+	*
		cp	4/5	–	+	–	+	+	–
	3	Mid.	5/3	–	+	+	–	+	–
			5/26	+	–	–	*	–	*
		cp	4/5	–	–	+	–	+	–
		Surf.	5/3	–	+	+	+	+	–
			5/26	+	–	+	*	–	–
		cp	4/5	–	+	+	+	+	–
Pil.	1	Mid.	5/3	–	–	+	–	+	–
			5/26	+	+	–	+	–	+
		cp	4/5	+	+	–	+	+	–
		Surf.	5/3	+	–	–	+	+	–
			5/26	+	–	+	–	+	–
		cp	4/5	+	–	–	–	+	–
	2	Mid.	5/3	–	–	+	–	+	*
			5/26	–	–	+	–	–	*
		cp	4/5	–	–	+	–	+	*
		Surf.	5/3	+	–	–	–		
			5/26	–	+	*			
		cp	4/5	*	–	–			
	3	Mid.	5/3	*	–	+	–	*	+
			5/26	–	–	+	–	–	–
		cp	4/5	–	–	+	–	–	*
		Surf.	5/3	–	+	–	+	+	+
			5/26	+	–	+	–	–	+
		cp	4/5	+	+	–	+	–	+
M	1	Mid.	5/3	–	+	+	*	–	+
			5/26	+	–	+	–	+	*
		cp	4/5	–	+	+	–	+	+
		Surf.	5/3	–	+	+	+		
			5/26	–	+	+	–		
		cp	4/5	–	+	+	+		
	2	Mid.	5/3	–	+	–	+	–	–
			5/26	+	–	*	–	+	*
		cp	4/5	*	+	–	+	–	–
		Surf.	5/3	–	+	*	+	+	*
			5/26	+	–	–	–	–	*
		cp	4/5	–	+	–	–	–	*
	3	Mid.	5/3	–	+	+	–	+	+
			5/26	–	+	+	–	+	*
		cp	4/5	–	+	+	–	+	+
		Surf.	5/3	–	+	+	+	–	+
			5/26	+	–	*	+	+	–
		cp	4/5	–	+	+	+	–	*

TABLE 9.—Continued

Differences Between Successive Samplings of Sugars in Normal Storage

Mark	No.	Part of Bag	Date	Pol.	Moist. %	R. S. %	M. R.	Mic.	Molds.
Ag.	1	Mid.	5/3	−	+	+	+	+	*
			5/26	+	−	−	−	+	+
		cp	4/5	−	+	−	−	+	+
		Surf.	5/3	−	+	−	+	+	+
			5/26	+	+	+	+	+	−
		cp	4/5	−	+	−	+	+	*
	2	Mid.	5/3	−	+	+	+	+	*
			5/26	+	−	−	−	+	+
		cp	4/5	−	+	+	+	+	+
		Surf.	5/3	−	+	−	+	+	−
			5/26	+	−	+	−	−	−
		cp	4/5	−	+	−	+	−	−
	3	Mid.	5/3	−	+	+	*	+	−
			5/26	*	+	+	+	+	−
		cp	4/5	−	+	+	+	+	−
		Surf.	5/3	−	+	+	+	+	−
			5/26	+	−	−	−	+	+
		cp	4/5	−	+	−	+	+	−

*No change.
+Increase.
—Decrease.
**Cp.—Third sampling compared with first.

The temperature and relative humidity in New Orleans during the months of storage of these sugars is given in Table 8. It may be said that in 1920 these were somewhat lower than the average.

In Table 9 is graphically represented the differences between successive samplings, together with a comparison between the last sampling and the first. There is a fairly close agreement to be found between the results for bags of one mark; therefore, these bags have been summarized in Table 10.

TABLE 10.

Summary of Differences Between Successive Samplings.
(Average of Bags of same Mark.)

Mark	No.	Part of Bag	Date	Pol.	Moist. %	R. S. %	M. R.	Mic.	Molds
F	1-3	Mid.	4/15	–	–	+	–	+	–
			5/13	–	+	+	*	–	+
		cp	3/18	–	+	+	–	–	*
		Surf.	4/15	–	+	+	–	+	–
			5/13	–	+	–	+	–	*
		cp	3/18	–	–	+	–	+	*
Port	1-3	Mid.	4/15	–	–	–	–	+	*
			5/13	–	+	–	+	+	–
		cp	3/18	–	+	–	+	+	–
		Surf.	4/15	*	–	–	–	+	*
			5/13	–	+	–	+	+	*
		cp	3/18	–	*	–	–	+	*
Cun	1-6	Mid.	4/9	–	+	*	+	+	–
			5/17	–	+	+	+	+	–
		cp	3/22	–	+	*	+	+	*
		Surf.	4/9	*	+	–	+	+	–
			5/17	–	+	*	–	+	*
		cp	3/22	–	+	–	*	+	–
Agr	1-3	Mid.	4/27	–	+	–	–	+	+
			5/21	–	–	+	*	+	+
		cp	3/30	–	+	–	+	+	+
		Surf.	4/27	–	+	–	*	+	+
			5/21	–	*	*	–	–	–
		cp	3/30	–	+	–	–	–	*
Cab	1-3	Mid.	4/27	*	+	–	+	+	*
			5/21	+	+	–	+	+	+
		cp	3/30	+	+	–	+	+	*
		Surf.	4/27	+	–	–	*	+	*
			5/21	*	+	–	+	–	*
		cp	3/30	+	–	–	*	+	–
Am	1-6	Mid.	4/29	–	–	+	–	+	*
			5/24	–	+	+	*	–	–
		cp	4/1	–	*	+	–	–	–
		Surf.	4/29	–	+	+	–	+	–
			5/24	–	*	+	–	–	+
			4/1	–	*	+	–	*	–
O	1-3	Mid.	5/3	–	+	+	–	–	–
			5/26	+	–	*	*	–	*
		cp	4/5	–	–	+	–	+	–
		Surf.	5/3	–	+	+	+	+	*
			5/26	+	–	+	*	+	–
		cp	4/5	–	+	*	+	+	–
Pil	1-3	Mid.	5/3	–	–	+	–	+	*
			5/26	–	–	+	*	–	*
		cp	4/5	–	–	+	–	+	*
		Surf.	5/3	+	–	–	–	+	–
			5/26	+	–	+	*	*	–
		cp	4/5	*	–	–	+	*	–
M	1-3	Mid.	5/3	–	+	+	*	–	+
			5/26	+	–	+	–	+	*
		cp	4/5	–	+	+	–	+	+
		Surf.	5/3	–	+	+	+	*	+
			5/26	+	–	+	–	*	–
		cp	4/5	–	+	+	+	–	*
Ag.	1-3	Mid.	5/3	–	+	+	+	+	*
			5/26	+	–	–	–	+	+
		cp	4/5	–	+	+	+	+	–
		Surf.	5/3	–	+	–	+	+	–
			5/26	+	–	+	–	+	–
		cp	4/5	–	+	–	+	+	–

cp—Compared with.

It will be seen that in practically all instances there has been a reduction in polarization between successive samplings. With regard to moisture content, however, there appears, on the contrary, to be an increase in a majority of instances. It is interesting in this connection to note that (with the exception of the Cab sugars) an increase in polarization is accompanied by a decrease in moisture content. Naturally, this means that there has actually been a loss (in weight) of sugar. Furthermore, it will be seen that the surface of each bag decreased in moisture content, or dried out, as might be expected, much more rapidly than the middle of the same bag. In the sugars which have deteriorated it will be observed that there has been an increase in per cent reducing sugars in successive samplings. However, as a rule, this increase is more noticeable in the middle of the bag than at the surface, where the deterioration does continue to progress at the initial rate. The conditions of temperature and humidity were such as to preclude the possibility of deterioration taking place more rapidly from the surface of the bag than the interior of the bag, as occurs under average conditions which were noted in the previous experiment. The moisture ratio was variable and does not permit of any generalization.

In considering the number of microörganisms it will be seen that in most instances there was an increase between successive samplings. In general, it was found in corroboration of the results previously set forth that the increase in numbers of microorganisms was relatively more rapid during the first month of incubation than subsequently. Likewise, it is to be noted that there is usually a greater number of microörganisms in the middle of the bag than at the surface, where drying out occurs. It will be shown in Table 11, which is again corroborative of previous work, that there is correlation between the number of microorganisms and deterioration where the initial content is high or multiplication has been rapid. The per cent of molds is quite variable, and a tendency to decrease in the surface is to be noted during the first four weeks of incubation. It is evident, therefore, that these results agree very closely with those previously obtained and this is of added significance when it is remembered that the range in variety of sugars is considerably greater.

TABLE 11.

Summary Showing Correlation Between Deterioration and Number of Microorganisms.

Mark	No.	Part of Bag	Sampling	Loss S. P.	Gain R. S.	No. Microorganisms Present
Am.	1	Mid.	3rd	2.5	2.30	120,000
		Surf.	3rd	3.5	1.93	4,900
Cun	4	Surf.	3rd	3.0	1.63	20,000
		Mid.	3rd	3.2	1.58	100,000
Am.	5	Mid.	3rd	2.0	1.60	115,000
Am.	3	Mid.	3rd	2.3	1.38	50,000
Am.	3	Surf.	3rd	1.8	1.38	4,000
Am.	3	Mid.	3rd	1.0	1.31	65,000
F.	1	Mid.	3rd	1.8	1.30	1,650,000
Am.	5	Mid.	2nd	1.6	1.23	70,000
Am.	6	Mid.	3rd	1.2	1.22	120,000
Am.	1	Mid.	2nd	1.2	1.10	4,000
M.	3	Mid.	3rd	1.1	1.05	100,000
Am.	3	Mid.	2nd	0.5	1.02	30,000

Table 11 consists of a summary arranged in such a manner as to bring out clearly the correlation between the number of microorganisms and deterioration. The order of bags is based upon the increase in reducing sugars, since that represents the best criterion for determining deterioration. In addition, it will be noted that the loss in polarization is proportional to the gain in reducing sugars. Still more significant, however, is the fact that deterioration occurs in the presence of the maximum numbers of microörganisms. It may be mentioned that the number of microorganisms set down opposite any figure for gain in reducing sugars is the number occurring at the previous sampling, since that number was responsible for the deterioration found at the time of analysis. With three exceptions the greatest deterioration is to be found when there are more than 20,000 microörganisms per gm. and the average for the deterioration represented by an increase of more than 1 per cent of reducing sugars is 174,000 per gm. It is interesting to compare Table 11 with Table 12,

TABLE 12.

Summary Showing Maximum Numbers of Microorganisms Where No Deterioration Occurs.

Mark	No.	Part of Bag	No. of Microorganisms
P.	1	Middle	6,000
		Surface	7,000
P.	2	Middle	6,000
		Surface	8,000
P.	3	Middle	2,100
		Surface	22,000
C.	1	Middle	8,000
		Surface	1,100
C.	3	Middle	5,000
		Surface	14,000
C.	6	Middle	22,000
		Surface	1,000
Agr.	1	Middle	3,100
Agr.	3	Middle	1,800
		Surface	300
Cab	2	Middle	2,000
		Surface	500
Cab	3	Surface	110,000
M.	3	Middle	1,050
		Surface	370
Ag.	1	Surface	2,600
Ag.	2	Surface	4,500
Pil.	1	Surface	24 500

which is a summary showing the maximum numbers of microorganisms where no deterioration has occurred. It will be seen at a glance that in only five instances has this number exceeded 8,000 per gm.; the average being about 11,000 (unduly weighted because of the Cab sugar, which was especially heavily infected). Thus a comparison between Table 5 and Table 6 reveals quite clearly that large number of microörganisms are casually related to deterioration, and the converse is likewise true.

TABLE 13.

Sugars Ranked According to Greatest Loss in Polarization During Normal Storage.

Rank	Mark	Part of Bag	Ave. Loss in Pol. per Bag	Rank	Mark	Part of Bag	Ave. Loss in Pol. per Bag
1	Am.	Mid.	1.5	1	Am.	Surf.	0.8
2	F.	Mid.	0.9	2	M	Surf.	0.8
3	Cun	Mid.	0.7	3	Cun	Surf.	0.7
4	Agr.	Mid.	0.6	4	Ag.	Surf.	0.6
5	M.	Mid.	0.5	5	F.	Surf.	0.5
6	Ag.	Mid.	0.4	6	O.	Surf.	0.4
7	Pil.	Mid.	0.3	7	Pil.	Surf.	0.3
8	O.	Mid.	0.2	8	Agr.	Surf.	0.2
9	Port	Mid.	0.2	9	Port	Surf.	0.1
10	Cab	Mid.	0	10	Cab	Surf.	0

In Table 13 the sugars analyzed have been ranked according to deterioration as based upon the greatest loss of polarization during normal storage. In compiling these data the analyses for all the bags of each mark were averaged. It is evident that the deterioration in the first six sugars mentioned was appreciable, the Am. sugar being considerably more deteriorated than any others. This sugar came by railroad, as did the O and Pil sugars, consequently it would be difficult to regard this as the sole limiting factor. Since the former had a higher moisture ratio and considerably more microörganisms per gm., it is natural to suppose that it would deteriorate more rapidly under any environmental conditions.

It is interesting to note further in Table 13 that in the majority of cases the rank of sugars with regard to deterioration is the same for the middle of the bag and for the surface. For example, the Am. sugar shows greatest deterioration both in middle and surface, while the Port and Cab sugars show least in both cases.

It has been shown that it is possible to predict the keeping quality of a sugar (from the standpoint of mold infection) by the simultaneous consideration of moisture ratio and number of organisms per gm.[7] Evidence for a prediction based on the number of bacteria was likewise advanced. In Table 7 the plus and minus signs next to the columns labelled "Moisture Ratio" and "No. of Mic. per gm." represent the prediction of deterioration based upon these factors considered independently. In this case we have taken the critical moisture ratio as .30 and the number of bacteria per gm. as 200, which are required to produce deterioration as shown in Table 14 in four weeks at this temperature and humidity of incubation. Where these conditions were higher, as in the experiment of 1919, then less than half this number of microörganisms will produce similar effects. If attention is focused upon the moisture ratio it will be seen that the factor of safety as worked out by previous investigators holds true to a limited extent. In other words, where the moisture ratio is above .30-.33 deterioration generally sets in, while sugars with lower moisture ratios generally resist deterioration. However, there are any number of instances where this factor of safety fails to function as an adequate criterion and we may turn with some confidence to the number of microörganisms per gm. as a true index of deterioration. In fact, a careful analysis of the data presented in Table 7 shows that as a criterion for predicting deterioration the moisture ratio or factor of safety

TABLE 14.

Correlation of Moisture Ratio with Number of Microorganisms.

Moisture Ratio.

No. of Mic. Per gm.	.18 – .21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42 +
0-100								–														–
100-200	*	+		*	*		*	+		*		+				–	+					
200-300	+				–	*	+		–	*	+		+			–	–				–	
300-400	*	+			*	–				–	*	+					–					
400-500	*		*			+	*				*		+	–			–					
500-1,000							*		–	*		–				–						+
1,000-5,000	+			*		+		–	+	+	–		–	+		–			*			
5,000-10,000									–							*	+			+		+
10,000-25,000				–								–			+	–				+		+
25,000-50.000							–									+						+
50,000-100,000			+			+		*				+						*				
100,000-250,000				+	+			+						–	+	+	+	+			+	+
250,000-500,000								–	*											+		–
500,000-1,000,000				+																		
1,000,000-5,000,000																	+		+			
5,000,000- +																	+					

+Deterioration.
–No deterioration.
*Doubtful deterioration.

proved to be in agreement with the analysis in 57 instances and failed in 86 instances; in other words, was only 40 per cent effective. On the other hand, using the number of microörganisms per gm. as an index of deterioration, resulted in 96 successful predictions and 47 failures, or an efficiency of 67 per cent, which is 27 per cent better than the factor of safety. In the 65 cases where the moisture ratio is in agreement with number of microörganisms for the theoretical prediction of deterioration, there was practical confirmation in the majority of instances.

It will be seen from Table 14, where there has been graphically illustrated the correlation between moisture ratio and number of microörganisms per gm., that, while such a relationship is of necessity dependent upon the environmental conditions at hand and it is hazardous in consequence to derive any didactic conclusions, nevertheless certain generalizations appear significant. For example, with more than 50,000 microörganisms per gm. in practically all instances there was deterioration at every moisture ratio employed. As the number of microörganisms is increased beyond this point it is almost certain that deterioration will occur at any moisture ratio generally occurring in Cuban raw sugar. As the number of organisms per gm. is decreased down to about 500 we have evidence of less deterioration at moisture ratios below .36. However, where the moisture ratio remains above .36 deterioration is effected by more than this number. On the other hand, even where the moisture ratio is reduced below .30, which is considered the critical point, there is ample evidence to indicate that deterioration may be induced by more than 200 microörganisms per gm. This corroborates the conclusions arrived at in the investigations previously referred to (6 and 7) and emphasizes again the necessity for reducing the mass infection in sugar. Thus, on the basis of polarization, moisture content, and bacteriological analysis, it is possible to predict the keeping quality of sugar and thereby introduce considerable economy by immediately disposing of those sugars which will deteriorate rapidly and storing only those proven to be capable of storage without serious loss. As a matter of actual manufacture, it should not be difficult to control the microörganisms to such an extent as to inhibit their detrimental activities. In this connection it may be stated that recent experiments have enabled us to develop a method for eliminating the microörganisms in sugar—namely, by the use of superheated steam in the centrifugal, which decimates over 90 per cent of the microörganisms, as shown in Part I.

It is therefore evident that sugar deterioration depends upon the two factors of moisture ratio and number of microörganisms per gm. Further, that if the latter is sufficiently reduced, as can be effected in the method described elsewhere, and the former properly controlled, sugar deterioration may be satisfactorily prevented.

SUMMARY.

1. From the results presented a correlation has been established between deterioration and the number of microörganisms, together with the moisture ratio. This makes it possible, as previously stated, to predict the keeping quality of sugar by a preliminary bacteriological and chemical analysis.
2. From 3 to 6 bags Cuban raw sugars each of 10 different marks, with moisture ratios varying from .18 to .50, were stored under normal conditions in a large warehouse and analyzed chemically and bacteriologically at the beginning and after 4 and 8 weeks respectively. There was a loss in polarization in most of the sugars at the end of each period, which was generally accompanied by a gain in reducing sugars and moisture content.
3. There was a decided increase in the number of microörganisms per gm., especially during the first four weeks, which could be correlated, within certain limitations, with deterioration. In general there were more microörganisms in the middle of the bag than at the surface. A large initial infection or rapid multiplication of microörganisms was responsible for an increase in deterioration.
4. It has been shown that the use of superheated steam in the centrifugal will reduce the number of microörganisms more than 90 per cent and consequently may eliminate deterioration if the moisture ratio, etc., are likewise properly controlled.

PART IV

THE FORMATION OF THE GUM, LEVAN, BY MOLD SPORES*.

IDENTIFICATION AND QUANTITATIVE DETERMINATION.

As has been stated, the formation of the gum, levan, during the bacterial decomposition of sugar has been noted by Greig-Smith and Steel[4] and Owen[8]. The former and Taggart[10] agree in the identification of chemical and physical properties of this bacterial gum called levan. In a consideration of the microbiological agencies responsible for sugar deterioration we have found that molds are by far the most dangerous single group of microörganisms normally occurring in sugars of all descriptions.[6] However, in establishing the fact that mold spores contain enzymes and can therefore cause the inversion of sucrose without germination or growth, it is also noteworthy to observe that mold spores contain an enzyme which can produce gum in sterile sugar solutions[7] of 10 and 20 per cent concentration. In order to identify this gum the following procedure was employed.

IDENTIFICATION OF LEVAN.

A pure pedigree culture of *Aspergillus Sydowi* Bainier was used to seed a large number of Petri dishes containing Kopeloff's agar.[6] After the spores had developed in profusion they were floated off the plates with sterile distilled water on to a sterile filter paper (Whatman No. 4) and washed thoroughly (about 100 cc. sterile distilled water per plate being used). The mold spores were washed into a sterile flask, 10 per cent of chloroform added and the suspension heated to 62.5°C. for one hour. The suspension was thoroughly ground with sterile sand and then added to 500 cc. portions of sterile 10 per cent sugar solution and incubated at 40°C. for ten days. The solutions were shaken frequently and found to be sterile on plating out at the end of this period. Ten cc. of the sugar solution from control flasks uninoculated, when made up to 50 cc. volume, gave a single polarization of 13.2°V., while 10 cc. of the gum solution similarly diluted with alcohol gave a single polarization of 5.3.

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*Read at the St. Louis meeting of the Sugar Division of the American Chemical Society April, 1920.

The supernatant gum solution was then siphoned from each flask without disturbing the spore residue, which was discarded. Five volumes of 95 per cent ethyl alcohol were added to the gum solution, which had been made alkaline with NaOH, the solutions being shaken thoroughly at frequent intervals and permitted to stand overnight at room temperature. The alcoholic supernatant liquid was removed and the precipitated gum thoroughly washed with successive portions of alcohol. The precipitate was then dissolved in the least possible amount of cold sterile distilled water and shaken thoroughly in a shaking machine for four hours. Again the gum was precipitated by alcohol in the manner described above and the process repeated several times until a white flocculent precipitate was obtained. This was partially dried on filter paper and finally transferred to an unglazed porcelain plate, where it remained for 18 hours at 20°C. The dry gum was then powdered and used for the following determinations.

The specific rotation of this gum was about —40 when using a .25 per cent solution, as may be seen in Table 15.

TABLE 15.

Chemical Composition of Levan Produced by Mold Spores.

	Moisture %	Ash %	Hydrolysis	Melting Point
−40.9	0.17	0.16	−87.3−90.0	200°C.

The moisture content was 0.17 per cent and ash 0.16 per cent. After hydrolysis with concentrated hydrochloric acid, the specific rotation was about —87 to —90, which coincides with the results obtained by Greig-Smith[4] and Taggart[10], and indicates that the gum hydrolyzes quantitatively into levulose. The melting point was not sharply defined, but occurred at about 200°C., when the gum coalesced and puffed, rising sharply in the capillary tube.

The dry gum is light yellowish-gray, giving a blue-gray opaque solution with water. It does not separate from semi-solution when allowed to stand for periods of time, or when centrifuged. The effects of various reagents are included in Table 16.

TABLE 16.

Effect of Reagents on Levan.

Treatment	*Result*
Oxidation with concentrated nitric acid, boiling,	Oxalic acid.
Cold water,	Soluble
Hot water solution after cooling,	Mucilaginous.
Prolonged heating 100°	Unchanged.
Acid hydrolysis,	Levulose.
Baryta,	Precipitate.
Lime water,	No precipitate.
Milk of lime,	Precipitate.
Strontia,	Precipitate.
Lead subacetate,	Precipitate.
Ammonium lead acetate,	Precipitate.
Litharge cold,	Not dissolved.
Fehling's solution,	Not reduced.
Ammoniacal mercuric nitrate,	Not reduced.
Iodine,	No blue.
Cuprammonium,	Dissolves (does not deposit on standing.)
Copper Sulfate,	Precipitate.
Ferric chloride,	No precipitate.
Tannic acid,	No precipitate
Acid nitrate mercuric,	No precipitate.

With two exceptions—namely, precipitation by copper sulfate and lead subacetate, which is probably due to some impurities in the small amount of ash—these results coincide with the same data presented by Greig-Smith and Steel[4] and Taggart[10], and we are therefore led to conclude that the gum under consideration which is formed by the enzymes in mold spores is none other than *levan.*

Previously we have noted the formation of levan in sugar solutions of varying concentration[7] and the data in Table 17 are further corroborative of the fact that the enzymes in mold spores causing inversion and levan production are active in highly concentrated sugar solutions, as, for example, 55 per cent in this instance.

TABLE 17.

The Formation of Levan in 55 Per Cent Sugar Solutions.

Inoculum	S. P.	R. S. %	Gum %
Check	55.1	2.29	—
Mold spores	51.7	4.63	1.54

(All data in this and succeeding tables represent the average of closely agreeing triplicate determinations, unless otherwise stated.)

THE DETERMINATION OF THE TRUE SUCROSE IN THE PRESENCE OF GUM.

It has been a matter of universal experience that the presence of a gum such as levan makes the polarization of a sugar solution very difficult and, furthermore, renders both single polarization and Clerget liable to errors of considerable magnitude, the former generally giving a lower value and the latter a higher value than that of the sucrose actually present. In making single polarizations of sugar solutions where levan is present it has been our custom, wherever necessary, to remove the levan by precipitation with alcohol. However, even this method fails to give the true content of sucrose, and therefore it was necessary to develop some more adequate means of making this determination, the details of which follow.

Since the Clerget method involves a minus reading and is based on the use of hydrochloric acid, which has been shown to hydrolyze the gum to levulose, it will readily be seen that the reading will be still further magnified in a negative direction. Therefore, it was necessary to employ a method which would not affect the gum, but would give the true sucrose content. The invertase method of Hudson[5] was found to fulfill these requirements.* A strong invertase solution was prepared by breaking up five pounds of Fleischmann's yeast in a mortar, placing it in a wide-mouthed 10 L. bottle with ground glass stopper, adding 125 cc. of c. p. toluene (which is slightly more than the amount recommended by Hudson, while also omitting the addition of water), and keeping it at 20°C. On each day following a portion of the liquefied mass was filtered and 5 cc. of the extract added to 95cc. of a 10 per cent sugar solution. Two drops of glacial acetic acid were added to both the check flask containing 100 cc. of the sugar solution and the treated solution and held at 30°C. (Both the check flask and that containing 95 cc. of sugar solution, as well as the yeast extract, were held at 30°C. for 10-15 minutes until the contents attained the constant temperature before addition of the yeast contract.) The initial time was noted and polariscope readings made every minute until one-half of the sucrose was inverted. The first day following the addition of toluene to the yeast the extract took 10.5 minutes to reduce the sucrose content one-half; the second day 6.7 minutes were required; the third day 5.6 minutes; the fourth day 4.3 minutes, and the fifth day 4.2 minutes. After the fourth day the bulk of yeast was placed on a large filter paper and the filtrate caught in a sterile flask containing 25 cc. toluene. By permitting the filtrate to drip into the toluene and keeping the mouth of the receiving flask filled with cotton, the most favorable conditions of sepsis were obtained. Neutral lead acetate was added to the filtrate in a quantity sufficient to insure complete precipitation, and the solution centrifuged and decanted. This was again tested with neutral lead acetate and centrifuged in sterile tubes, the procedure being repeated until no precipitate was formed. The very slight excess of neutral lead acetate was removed in a similar manner by the addition of potassium oxalate 2N, centrifuging and decanting. The solution was covered with a layer of toluene and then dialyzed in a fish-skin membrane against running tap water for two days, and finally centrifuged and decanted. The invertase solution thus prepared was covered with a layer of toluene and kept in a sterile ground glass stoppered bottle in the refrigerator. It was active enough to completely invert a 10 per cent sugar solution in less than 20 hours at room temperature. In order to compare the efficiency of the invertase solution thus prepared with the Clerget method of hydrochloric acid inversion, several samples of standard granulated (refined) sugar cane syrup and 10 per cent sugar solutions were used, the latter with and without the addition of levan. Normal weights (26 gm.) of the materials under consideration were weighed out and made up to 100 cc. For the Clerget determinations 25 cc. of distilled water were added to 50 cc. of solution in a 100 cc. flask, 25 cc. water added, 5 cc. concentrated hydrochloric acid, the solution heated to 67-69° C. in three minutes and held at 69° C. for an additional seven minutes, then cooled in an ice bath to a temperature several degrees below that of the room, made up to the mark and polarized at the same temperature as the solutions for single polarization. For the invertase method 5 cc. of invertase were added to 50 cc. of solution made very slightly acid with 10 per cent acetic acid, distilled water added up to the mark, 1 cc. of toluene added and the flasks covered with a watch crystal and incubated at room temperature for 22 hours.

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*This procedure was suggested by Assistant Director W. G. Taggart, to whom we are indebted for continued and invaluable assistance.

TABLE 18.

Comparison of Clerget and Invertase Methods.

Solutions	Clerget % Sucrose	Invertase % Sucrose	Gum %
(1) Refined Sugar................	10.66	10.67	....
(2) Refined Sugar................	10.59	10.51	....
(3) Refined Sugar................	10.59	10.53	....
Cane Syrup.....................	43.47	43.20	....
1.5% Levan in 10% Sugar Solution	11.26	10.17	1.38
.59% Levan in 10% Sugar Solution	11.00	10.58	.53
.33% Levan in 10% Sugar Solution	10.89	10.57	.40

It will be seen from the data in Table 18 that the results obtained for refined sugar by the Invertase and Clerget methods agreeing very closely within the limits of experimental error. Only the averages of closely agreeing duplicate determinations being recorded. As might be expected, there is a slight discrepancy in the case of cane syrup. This experiment was repeated with similar results.

THE POLARISCOPIC DETERMINATION OF LEVAN.

It is of special interest to note that in addition to applying the invertase method to the determination of sucrose where gum is present, we have here likewise developed a method for the determination of the amount of gum present. In other words, we have two equations, the one for Clerget or acid inversion, the other for invertase, the difference representing the transformation of gum to levulose. Thus for acid and invertase inversion the following graphic representation may be made of the polarscopic value of a sugar solution containing gum as follows, where S=sucrose, D=dextrose, L=levulose, G=gum:

(a) Acid Inversion	—	×
Before inversion...	L + G	S + D
After inversion....	L + G as L + ½S to L	½S to D + D
(b) Invertase inversion	—	+
Before inversion...	L + G	S + D
After inversion....	L + G + ½S to L	½S to D + D

Therefore a — b = G to L. Since we know that the specific rotation of levan is —40 and that of d—fructose is —92.5, then the differences caused by hydrolysis of the levan is —52.5. Since the specific rotation of sucrose is + 66.5, for every per cent of gum in the solution, we have a change in rotation as follows:

$$\frac{66.5}{52.5} = 1.27.$$

Now the difference in sucrose (as may be seen in Table 18) determined by the Clerget and Invertase methods for 1.5 per cent levan in a sugar solution is 11.26 — 10.17, or 1.09. Therefore the per cent of gum present is 1.07 × 1.09, or 1.38. This is only 0.12 below the theoretical recovery. Similar results were found where smaller amounts of gum were present.

Thus an adequate method has been established for the quantitative determination of gum, but one which is more reliable for larger rather than smaller amounts of gum in sucrose solution.

SUMMARY.

1. Mold spores (*Aspergillus Sydowi* Bainier) contain an enzyme capable of forming gum in sucrose solutions of all concentrations up to the saturation point.
2. The specific rotation of the pure gum was found to be —40, and the melting point about 200°C. Upon hydrolysis levulose was formed.
3. This gum is *levan,* since its chemical and physical properties are identical with those described in the bacterial decomposition of sucrose.
4. The invertase method has been successfully applied in the determination of true sucrose in the presence of gum.
5. Levan may be quantitatively determined polariscopically by using a combination of the Clerget and Invertase methods.

PART V

THE FORMATION OF THE GUM, LEVAN, BY MOLD SPORES. MODE OF FORMATION AND INFLUENCE OF REACTION.

Various aspects of sugar deterioration have been considered, but there are few which are more interesting than the problem of the formation of gum from sugar. This is of practical importance because of its interference with the accurate determination of sucrose, as well as the actual loss in sucrose which the formation of gum represents. The organisms which are capable of producing gum from sucrose have already been described. While previous investigators have been chiefly concerned with the bacteria responsible, we have considered the molds more particularly.

In the preceding part dealing with this phenomenon we have discussed the identification and quantitative determination of levan. Perhaps the most baffling problem involving the presence of levan in sugar solutions is that concerned with its mode of formation. In an endeavor to throw some light upon this question the following experiments were conducted. Fifty cc. of sucrose solutions of varying concentration with and without the addition of c. p. dextrose and levulose were inoculated with 10 cc. mold spores with and without the addition of 2 cc. invertase (the latter used to furnish an abundant supply of nascent dextrose and levulose). Sterile distilled water was added to the checks, etc., in such a way as to have all the solutions of equal volume. The flasks after one week's incubation at 45°C. were analyzed for acidity, sucrose by single polarization, reducing sugars (volumetric) and gum by precipitation with alcohol in alkaline solution. and weighing upon tared filter papers.

TABLE 19.

The Formation of Levan by Mold Spores in Sugar Solutions of Varying Concentrations.

*A

Inoculum	S. P.	R. S. %	Gum %	Acidity takes 5 cc. N/10 Alk.
Check	7.5	1.26	0	.02
Mold Spores	6.5	1.47	.19	.02
Invertase	−2.8	10.00	0	.10
Spores and Invertase	−1.1	10.00	.06	.09

*B

Check	2.4	5.00	0	.07
Mold Spores	2.7	5.88	.13	.07
Invertase	−2.5	9.52	0	.19
Spores and Invertase	−1.0	8.69	.04	.16

*C

Check	−1.6	8.33	0	.13
Mold Spores	−1.7	8.69	.08	.13
Invertase	−2.3	8.69	0	.30
Spores and Invertase	−1.1	7.57	.04	.16

*D

Check	−2.0	8.69	0	.17
Mold Spores	−2.1	8.69	.12	.20
Invertase	−2.0	8.69	0	0
Spores and Invertase	−0.6	7.81	.11	.14

*A—10 per cent Sucrose.
*B— 5 per cent Sucrose + 2.5% each Dextrose and Levulose.
*C— 1 per cent Sucrose + 4.5% each Dextrose and Levulose.
*D— 5 per cent Dextrose and 5 per cent Levulose.

TABLE 20.

The Formation of Levan by Mold Spores in Sugar Solutions of Varying Concentrations.

A

Inoculum	S. P.	Loss S. P.	R. S. %	Gain R. S. %	Gum %	15 cc Takes N/20 Alk.	Ph.
Check	8.0	....	.17	....	0	.30	7.1
Mold Spores	5.9	2.1	2.14	1.97	.16	.06	7.0
Invertase	−2.2	10.2	8.47	8.30	0	.35	5.1
Spores and Invertase	−0.8	8.8	8.58	8.41	.08	.32	6.7

B

Inoculum	S. P.	Loss S. P.	R. S. %	Gain R. S. %	Gum %	15 cc Takes N/20 Alk.	Ph.
Check	2.4	....	4.43	....	0	.28	4.7
Mold Spores	1.8	0.6	5.77	1.34	.08	.42	6.7
Invertase	−0.5	2.9	8.33	3.90	0	.45	4.9
Spores and Invertase	0.6	1.8	7.69	3.26	*	.34	6.5

C

Inoculum	S. P.	Loss S. P.	R. S. %	Gain R. S. %	Gum %	15 cc Takes N/20 Alk.	Ph.
Check	−0.9	....	7.32	....	0	.40	4.6
Mold Spores	−0.2	....	7.51	0.19	*	.62	6.2
Invertase	−1.6	0.7	8.33	1.01	0	.30	6.2
Spores and Invertase	−0.5	0.4	7.69	0.37	*	.48	6.3

D

Inoculum	S. P.	Loss S. P.	R. S. %	Gain R. S. %	Gum %	15 cc Takes N/20 Alk.	Ph.
Check	−1.8	....	7.69	....	0	.70	4.7
Mold Spores	−0.5	....	7.69	....	*	.64	6.1
Invertase	−1.8	....	7.69	....	0	.70	5.0
Spores and Invertase	−0.5	....	7.32	....	.01	.61	6.2

*Negligible amounts.

TABLE 21.

The Formation of Levan by Mold Spores in Sugar Solutions of Varying Concentrations.

	1% Sucrose + 4.5% Dextrose + 4.5% Levulose				5% Dextrose + 5% Levulose			
Inoculum	S. P.	Loss S. P.	R. S. %	Gum %	S. P.	Loss S. P.	R. S. %	Gum %
Check	−1.4	......	8.69	0	−2.0	......	8.96	0
Mold Spores	−0.3	−1.1	8.82	.07	−0.5	−1.5	9.09	.06
Spores and Invertase	−0.5	−0.9	8.89	.06	−0.5	−1.5	8.96	.06

While there is considerable variation in the results presented in Tables 19-21, nevertheless certain generalizations may be made. In the first place, it may be seen in Table 19, where there were present 34,000 spores per solution, that there is a direct relation between the amount of sucrose present and the quantity of levan formed, *i. e.*, the largest amount of gum where mold spores are present is .19 per cent in 10 per cent sucrose alone. In 5 per cent sucrose the gum drops to .13 per cent and in 1 per cent sucrose the gum is only .08 per cent. Similarly in Table 20, where there were 47,000 spores per cc. of solution, the more sucrose present the greater is the gum formation. This is in agreement with Owen's[8] conclusions based on the formation of levan by bacteria. The increase in reducing sugars (dextrose and levulose, both c. p.) bears an inverse relation to the gum formation when only spores are present. On the other hand, where invertase has been added to the spores, the largest levan production occurs where there is a greater supply of reducing sugars. This may simply be a corollary to the fact that the greatest amount of reducing sugars occurs where the sucrose content is highest. In this connection it might be well to consider the differences in acidity as measured in terms of N/10 NaOH and in the later tables in Ph. While, as a rule, there is an increase in acidity where invertase has been added to mold spores, this does not appear to be of sufficient magnitude to account for the differences obtained. It will be observed that when the polarizations of sugar solutions inoculated with invertase and mold spores are compared with invertase alone, almost invariably the latter is higher than the former, and this despite the fact that an inoculation of mold spores causes a reduction in polarization when compared with the checks because some of the nascent reducing sugars from sucrose are used in gum formation. An explanation may be found in the fact that the true acidity of the solutions containing invertase is greater than where mold spores have been added, and similarly the true acidity of the check solutions was generally higher than where mold spores had been added. This was obscured in the method of titrating 15 cc. of the solution with N/10 NaOH, using phenolphthalein as an indicator, for in such cases the apparent acidity indicated was greater in the case of an inoculation with mold spores than in the checks.

However, by adopting the methods and procedure outlined by Clark and Lubs[3] in their notable application of physical chemistry to bacteriology, it was found that the Ph values obtained made certain important facts evident—namely, that the Ph values of the mold spore inoculation indicated the presence of less true acidity than was to be found in the checks, consequently it is to be expected that the presence of mold spores would tend to reduce the acidity present where invertase was used. This condition also accounts for the fact that in the solutions containing invertase and mold spores there was less gum formed than where mold spores alone were used, and gum formation is best aided by the absence of acidity. It would be of interest in this connection to compare spore suspensions of many fungi with a view to ascertaining the Ph values, and this study will be carried out in the near future.

It will be seen from the Tables 19-21 that in the absence of sucrose in solutions containing 5 per cent each of c. p. dextrose and levulose that there has been as much gum formed as in solutions containing 1 per cent of sucrose and 4.5 per cent each of dextrose and levulose. These data contradict those of previous investigators in that no formation of gum has heretofore been recorded where c. p. dextrose and levulose have been used without the addition of sucrose. In order to test these Merck chemicals for the presence of sucrose, normal weights of a 10 per cent solution were taken for single polarization and Clerget at room temperature (25-30°C.) for 20 hours. The solutions were brought to neutrality with strong NaOH and acidified with two drops of 10 per cent acetic acid before making up to the mark. The results obtained proved that these sugars were entirely free from sucrose which might influence gum formation. Such evidence would seem to indicate that the formation of gum from sucrose requires the intermediate formation of reducing sugars, whether in the nascent state or otherwise. A further discussion of this conclusion will be considered in the experiments which follow concerning the reaction of the medium.

THE INFLUENCE OF REACTION ON THE FORMATION OF GUM.

In order to approach the study of the formation of levan from still another angle, sucrose solutions with and without the addition of invertase were treated with varying amounts of alkali. Since an excess of hydroxyl ions will prevent the enzyme invertase from being active, it was hoped that a point of alkalinity might be obtained where the invertase would be inactivated, but the levanase perhaps function in the formation of gum, so that the fact could be established whether or not sterile N/10 NaOH was first added at the rate of 2, 3, and 4 cc. to 50 cc. of 10 per cent sugar solution, untreated, inoculated with mold spores plus 2 cc. invertase.

TABLE 22.

The Formation of Levan by Mold Spores in Sugar Solutions Receiving Alkali.

Inoculum	5 cc Solution takes N/10 Alk. cc.	Addition 2 cc. N/10 NaOH		
		S. P.	R. S. %	Gum %
Check	.02	6.4	1.49	0
Mold Spores	.02	5.9	1.92	.08
Spores and Invertase	.05	−0.5	8.33	.09
		Addition 3 cc. N/10 Alk.		
Check	.01	6.4	1.09	0
Mold Spores	.01	6.0	1.79	.09
Spores and Invertase	.03	4.5	3.03	.22
		Addition 4 cc. N/10 Alk.		
Check	.02	6.4	1.11	0
Mold Spores	.01	5.3	1.12	.07
Spores and Invertase	.03	4.4	3.23	.19

The results of one week's incubation at 43°C. are presented in Table 22, from which it appears evident that with 2 cc. of N/10 alkali there is practically no difference in the per cent of gum formed whether invertase is present or absent, while with 3 cc. of alkali there is a marked increase in gum formation in the presence of invertase. A further increase in alkalinity—namely, 4 cc.—gives similar results in lesser amount. These data indicate that the reaction of the medium is a limiting factor in the formation of levan from sucrose by mold spores, in so far as it influences invertase activity. It is quite evident that this activity is extremely sensitive to slight changes in reaction and becomes inhibited by any appreciable concentration of acidity or alkalinity.

The use of invertase in the above solutions was to insure an adequate source of *nascent* dextrose and levulose by the means of an agent which would not otherwise affect the biological processes involved. Naturally, there was always present an adequate supply of reducing sugars. Since the maximum gum formation occurs in the presence of invertase (with 3 cc. of alkali) and where there is actually a smaller amount of reducing sugars formed, it is apparent that the most favorable source of gum formation is the nascent dextrose and levulose formed from sucrose by invertase.

TABLE 23

Effect of Alkalinity on Formation of Levan by Mold Spores.

cc. Normal Alk.	CHECK			MOLD SPORES				MOLD SPORES AND INVERTASE			
	S. P.	R. S.	Ph.	S. P.	R. S.	Gum	Ph.	S. P.	R. S.	Gum	Ph.
0.3	8.1	.15	7.3	8.1	1.67	0.2	7.3	–0.5	8.33	.39b	7.0
0.4	9.0	.16	6.8	8.8	.49	*	7.3	1.0	7.18	.46b	6.7
0.5	8.8	.18	7.5	8.8	.36	0.5	7.9	0	8.46	.09	7.1
0.6	8.8	.20	7.1	9.1	.31	*	7.6	0.8	8.11	.34	7.1
0.7	8.3	.17	7.3	8.8	.20	*	7.5	0.6	7.03	.22b	6.6
0.8	8.3	.08	7.6	8.3	.18	0.2	7.8	2.0	6.06	.58b	6.9
1.0	8.3	.10	7.9	8.9	.06	*	8.1	1.2	7.14	0	7.1
1.5	8.4	.07	8.1	8.5	.10	*	8.3	8.4	.01	.01	7.6
2.0	8.3	.05	8.3	8.6	.06	.04	8.3	8.6	.06	0	7.3

*Negligible Amount.
b—Bacterial contamination.

In Table 23 similar data are presented employing a wider range of alkalinity varying from 0.3 to 2.0 cc. of normal NaOH per 50 cc. of 10 per cent sucrose solution. While these results are quite variable, due to a light inoculation of 24,000 spores per cc. of solution, nevertheless there again seems to be evidence to the effect that gum formation goes forward most favorably in the presence of invertase which is responsible for the presence of nascent dextrose and levulose. However, several of these solutions were contaminated with bacteria, which were probably responsible for some increase in gum formation. A point of considerable interest in this experiment is that the Ph values of the solutions containing mold spores were higher than the check flasks, showing again that the reaction of that inoculum tends to make the reaction of one medium more alkaline, while the addition of invertase invariably increases the acidity. It will be observed that the maximum gum formation occurred with the addition of 5 cc. of N/10 alkali or at a Ph value of 7.1, which is practically true neutrality (7.0 representing neutrality). Thus we are led to believe that the maximum gum formation occurs where nascent dextrose and levulose are available and the reaction of the medium is practically neutral.

TABLE 24.

Effect of Alkalinity on Formation of Levan by Mold Spores.

cc. Normal Alk.	Check			Mold Spores			Spores and Invertase		
	S. P.	R. S. %	Gum %	S. P.	R. S. %	Gum %	S. P.	R. S. %	Gum %
0.6	9.0	.22	0	8.5	.12	.10	6.5	2.67	.30
2.4	8 7	.14	0	8.8	.20	.04	8.7	.23	.09
3.6	8.5	.20	0	8.7	.15	.04	8.6	.14	.01
6.0	8.1	.13	0	8.4	.06	0	8.2	.07	0

The influence of marked changes in alkalinity of the medium is shown in Table 24, where there were 108,000 spores per cc. of solution where from 0.6 to 6.0 cc. of normal NaOH have been added to 70 cc. of 10 per cent sucrose solution. Here again the maximum gum formation occurs in the presence of nascent dextrose and levulose (invertase added) where the reaction is nearly neutral. In fact, three times as much gum is formed as where invertase has not been added. An increase in alkalinity causes an inhibition in invertase activity (as seen by the amount of reducing sugars present), and also a reduction in gum formation.

At the greatest concentration of alkalinity there were present sufficient hydroxyl ions to entirely stop invertase activity which is paralleled by the absence of gum formation, thus indicating the causal relationship previously referred to.

These experiments were repeated twice again, the results confirming those set forth above, but it is superfluous to include these data at this point.

In the light of the foregoing experimentation we are able to arrive at a satisfactory explanation of the phenomenon of gum formation in sterile sugar solutions inoculated with certain microorganisms. Namely, the formation of gum from sucrose depends upon the inversion of the latter. The most favorable conditions are those where nascent dextrose and levulose are present in abundance when the reaction is optimum or practically neutral (in terms of hydrogen ion concentration). We have arrived through somewhat different considerations to the same conclusion, in this respect, as that enunciated by Greig-Smith. There is, moreover, good reason to believe that nascent levulose is even a more favorable source for gum formation than nascent dextrose and that the reaction between levan and levulose (which is formed by hydrolysis) may be, to some extent, a reversible one. The basis for this hypothesis may be found in an examination of Table 21, where it is seen that there is an increase in polarization where nascent dextrose and levulose are being used as a source of gum formation, for the polarization of the controls is —2.0, while that of spores and invertase is only 0.5, indicating that more levulose than dextrose has been utilized. It follows that as a secondary source of supply an increase in sucrose involves an increase of nascent dextrose and levulose, consequently it is justifiable to state that gum formation likewise depends on sucrose. Furthermore, it is of interest to note that we have evidence to show that in the absence of sucrose or nascent dextrose and levulose, gum may be formed in small amounts from solutions containing c. p. dextrose and levulose present in equal quantities.

The above facts in no way conflict with the theoretical considerations governing the transformations which carbohydrates may undergo.

SUMMARY.

1. Levan is formed by levanase from mold spores most readily from nascent dextrose and levulose (obtained by the action of invertase on sucrose). There is evidence that nascent levulose is used to a greater extent than nascent dextrose in the formation of levan. In the absence of sucrose and nascent reducing sugars, slight gum formation was obtained with c. p. reducing sugars.
2. Levan is not formed directly from sucrose, but may be formed when the latter undergoes inversion.
3. Appreciable concentrations of acidity or alkalinity inhibit the activity of levanase. The optimum reaction appears to be about Ph 7.0.

PART VI

PRACTICAL DEDUCTIONS.

In arriving at any practical deductions based upon the foregoing investigations it is necessary to consider conditions as they exist in the average sugar mill and warehouse. Since mass infection results from air, water, soil, etc., laden with microörganisms, it is obvious that proper control will do much towards a reduction in numbers. Reference has been made to the fact that the massecuite is sterile when it leaves the vacuum pan. Therefore it is only necessary to employ safeguards from this point onward. We have recommended therefore that the conveyors for the massecuite be covered with a tarpaulin to prevent the entrance of foreign matter and large numbers of microörganisms. Following this, the most sanitary measures are desirable in and around the centrifugal. The wash water if used should be chemically treated for rendering it more sterile. The floor should be kept clean and disinfected frequently. The centrifugals should be covered, preferably, and located in a space walled off from the remainder of the mill. The use of superheated steam in the centrifugals instead of water for washing the sugar should be an important adjunct in obtaining sugars with a low content of microörganisms. Finally, a cool, well-ventilated warehouse is a prerequisite in inhibiting the deteriorative process.

It is common knowledge that the moisture ratio of sugars must be low to insure safekeeping, but similarly it is imperative to reduce the number of microörganisms. Finally, it is a matter of considerable economic moment to be able to predict the keeping quality of sugar so that it may be handled properly. This may be done by a determination of polarization moisture and micro-organic content.

ACKNOWLEDGMENT.

The authors wish to express their appreciation of the coöperation they have received from Assistant Director W. G. Taggart and Dr. F. W. Zerban, as well as the constructive criticism of Dr. C. A. Browne and Mr. W. L. Owen. To Mr. McFetridge, Mr. Salvant and his associates at the American Sugar Refinery at Chalmette are due thanks for having been able to conduct experimental work on a practical scale.

SUMMARY.

1. By the use of superheated steam in centrifugals it has been possible to reduce the number of microörganisms over 90 per cent, thereby eliminating one of the most important factors in sugar and molasses deterioration. This method is simple, economical and efficient.
2. A survey has been made of the deterioration of a large variety of Cuban raw sugars during normal storage. The results show that the number of microörganisms together with moisture ratio (or factor of safety) are the determining factors in sugar deterioration.
3. It was possible to predict from the above data whether or not deterioration would take place, thereby preventing serious losses.
4. Mold spores contain an enzyme capable of forming gum in sucrose solutions of all concentrations up to the saturation point.
5. The gum formed is levan, as indicated by its physical and chemical properties, having a specific rotation of —40°, a melting point of 200°C, and forming levulose on hydrolysis.
6. The Invertase method has been successfully applied in the

determination of true sucrose in the presence of gum. The gum may be quantitatively determined polariscopically by combining the Clerget and Invertase methods.

7. Levan is formed from nascent levulose and dextrose (obtained by the inversion of sucrose). There is evidence that the former is used to a greater extent in gum formation. In the absence of sucrose and nascent reducing sugars, slight gum formation was obtained with c. p. reducing sugars. Levan is not formed directly from sucrose but may be formed when the latter undergoes inversion.
8. Appreciable concentrations of acidity or alkalinity inhibit the activity of levanase, the optimum reaction being about Ph 7.0.

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A Method of Selecting L 511 Cane Free of the Mosaic Disease for Planting Purposes

BY

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RAMIRES-JONES PRINTING CO.
Baton Rouge

A METHOD OF SELECTING L511 CANE FREE OF THE MOSAIC DISEASE FOR PLANTING PURPOSES

C. W. EDGERTON.

One of the most serious problems before the Louisiana sugar planter at present is the mosaic disease of the cane. This trouble has been in the state for several years and during the past two years has been spreading very rapidly. It occurs on a large percent of the plantations along the Mississippi river and is scattered in other parts of the state. In some sections along the river, where the disease has been present for several years, nearly one hundred percent of the cane is affected, and in the rest of this district the infection averages from five to thirty percent.

This disease is undoubtedly doing considerable damage in this state. Experiments which have been carried on during the present season show that cane free of the disease grows off much faster than diseased cane and will unquestionably make heavier yields. Cane affected with the disease often makes a very good growth in a favorable situation, but it does not make the growth that healthy cane would under the same conditions.

The disease has become so widespread in Louisiana, not only upon cane but also upon sorghum, corn and a number of wild grasses, that there is but little hope of ever eradicating it completely. Consequently, in order to cut down their losses, the planters should take all known precautionary methods to check the spread of the disease and keep it under control. The control measures are not very well worked out as yet, but there are a few things that can be done which will be of material help. In this bulletin is described a method of selection of seed of one variety—the L 511—which, if followed consistently from year to year, will probably almost eliminate the loss with this variety.

Of all the commercial varieties of cane grown in this state, the L 511 is the most resistant to the mosaic disease. Even in those regions where ordinary varieties, such as D 95, D 74, Purple and Striped, show nearly one hundred percent infection with the mosaic disease, the L 511 rarely shows more than fifty or sixty percent and often considerably less. Also the disease spreads slowly in a field of L 511 cane as compared to the rapid spread which often takes place on the other varieties. This variety is also a most desirable cane in many other respects, and it is probable that it will become one of our leading varieties. In the few places where it is grown on a large enough scale to be important, it is recognized as a most desirable cane. The variety, consequently, becomes more valuable when it is realized that it shows some natural resistance to the mosaic disease.

One of the most promising methods of controlling the mosaic disease is by using disease-free seed for planting purposes. Disease-free seed will produce healthy stalks and infected seed

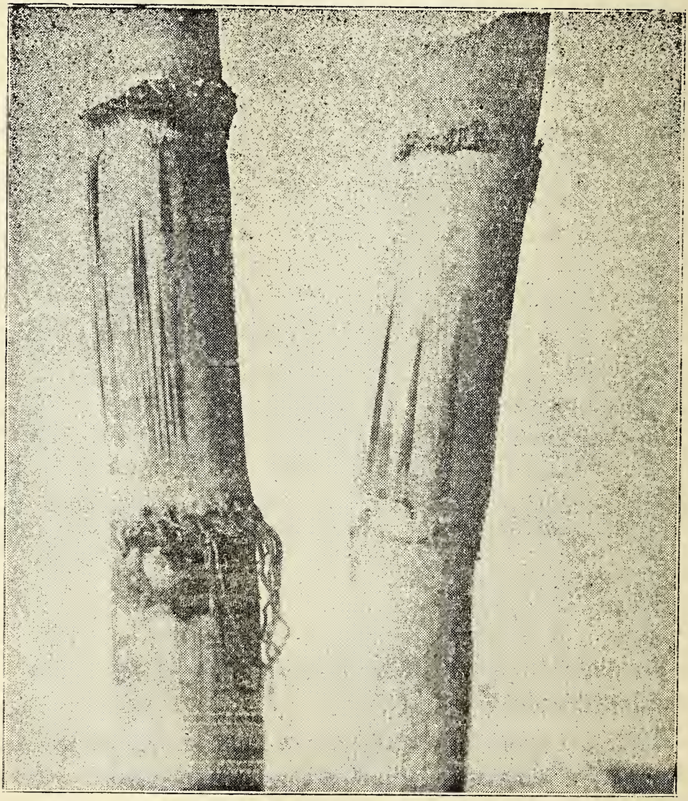

Figure 1. Stalks of L 511 cane affected with the mosaic disease. Red stripes on the stalks of this variety always show the presence of the disease.

will produce diseased stalks. If it were possible to plant disease-free seed and then prevent the secondary infection the following summer, the disease could be eliminated. Consequently, any method of selection that will insure disease-free seed constitutes a forward step in the control of the disease. In the tropics, and to a small extent in Louisiana, planters have shipped in seed from regions where the disease was not present. In Louisiana, such an operation is very expensive on account of the large amount of cane that is necessary for planting an acre. What is most desired is some method of selecting this disease-free seed on the plantation on which it is to be planted.

With the ordinary varieties of cane, such as D 74, D 95, Purple and Striped, the selection of seed cane free from mosaic in a field that contains the disease is slow and tedious, as well as expensive, work. To make sure that the stalks are not affected it is necessary to examine the leaves before the stalks are cut and stripped. This requires a man thoroughly acquainted with the disease to accompany the cutters.

With the L 511 variety, it is not necessary to examine the leaves, as the presence of the disease can be readily told by the appearance of the stalks. This makes the selection of disease-free seed a comparatively simple operation. The cane can be cut in the usual way, after which a man acquainted with the appearance of the disease can rapidly select out the healthy ones.

Healthy stalks of L 511 cane are greenish in color. They never show lines or stripes up and down the joints. Red stripes, however, are always present on diseased stalks, especially on the lower joints. These red stripes always run lengthwise of the stalk and they vary in width from mere lines up to an eighth of an inch. These stripes may be numerous on the stalk or they may be scattering, but the presence of a single one shows that the stalk is affected with the mosaic disease. Stalks of L 511 cane affected with the mosaic disease and showing these red stripes are illustrated in figure 1. In selecting L 511 cane for seed, all stalks that show these stripes should be thrown out and sent to the mill. With a little experience, a man can select the disease-free seed almost as rapidly as he can handle the stalks.

During the planting season of 1919, some experiments were started at the Audubon Park Sugar Station in New Orleans to test out the value of this method of selecting L 511 cane and also the value of planting healthy cane of other varieties in close proximity to diseased blocks of cane. Four rows an acre long were planted with selected, disease-free L 511 seed and the adjoining four rows were planted with seed that showed the presence of the mosaic disease by the red stripes on the stalks. It took less than an hour's time to select out enough disease-free seed to plant the four rows. The L 511 cane was growing on the station grounds where the mosaic disease had been present several years. At the same time, small plots were planted with disease-free seed of the varieties D 74 and D 95. This seed had been shipped in from a section of the state in which the disease does not as yet occur. These experiments were intended to give information not only on the possibility of selecting healthy seed in this manner, but also on the rapidity of the spread of the mosaic disease on the different varieties.

During the summer of 1920, the cane growing on the different plots was examined at frequent intervals. The first examination was made on May 25. On that date, there were but five diseased stalks in the four rows planted with selected, disease-free L 511 seed, while practically all of the stalks growing from the cane that showed red stripes had the disease. This low percent of disease showed that this method of selection was entirely satisfactory. Probably as many stalks would have slipped in if the seed had been examined in the field before cutting.

As the season advanced, there was some spread of the disease in the plot of selected L 511 cane. This was to be expected, as the plot was entirely surrounded by badly infected blocks of cane of various varieties, yet on September 2, a count showed that in one row there were only forty-eight diseased stalks, as against one hundred and thirty healthy ones. At the same time in the adjoining row, planted with diseased seed, there were one hundred and thirty-five diseased stalks and no healthy ones. It should also be noted that the cane in the plot from healthy seed grew much better and faster during the summer than the cane in the other plot.

Had these four rows of cane from selected seed been growing in an isolated place and the five diseased stalks removed in the spring, there is little doubt but what the cane would have remained practically free of the disease throughout the season.

In the plots of D 74 and D 95 cane planted with healthy seed, the young plants were healthy when they came through the ground in the spring, but the disease spread much faster in them than it did in the L 511 plot. By the middle of August, these plots showed one hundred percent infection with the mosaic disease. This experiment demonstrated that cane of the L 511 variety growing from disease-free seed selected from an infected field is more resistant to the mosaic disease than cane of these other varieties growing from seed from a non-infested locality.

Considering these experiments, it is believed that every planter who intends to grow L 511 cane will find it to his advantage to select disease-free seed for planting each fall. If he is only growing a small amount, it would be advisable for him to select the seed for the entire planting. If he is growing the cane on a large scale, it would be best for him to lay out a seed plot each fall. In this plot could be planted selected, disease-free seed and the following fall all the cane grown on the plot could be used for planting the main crop. If this system were followed consistently every year, it seems very probable that the loss due to this disease with this variety would be kept at a minimum.

Those planters who only have a small amount of L 511 cane and are increasing it as rapidly as possible from year to year, will find it to their advantage to select out all the healthy stalks and plant them in a separate plot. This will in a few years give them a better cane and much less of the disease.

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OF THE

Louisiana State University
and A. & M. College

Baton Rouge

Chemical Composition of Some Louisiana Soils As to Series and Texture.

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CHEMICAL COMPOSITION OF SOME LOUISIANA SOILS AS RELATED TO SOIL SERIES AND TO TEXTURE[1]

INTRODUCTION

One of the objects of the Louisiana State Soil Survey is to determine what relations, if any, exist between the chemical composition of soils and the classification of soils as defined and used by the United States Bureau of Soils. This classification system is based on the physical properties, such as color, texture, etc., and a consideration of the geological history of the soil. Such a system is extremely useful for rapid and extensive survey work, but it would obviously be much more valuable if one could judge a soil's chemical composition by knowing the type to which it belongs.

At least two important publications on this subject have appeared recently. Robinson and others[2] report chemical analyses of 34 soils and 35 subsoils, representing 30 soil types distributed in 6 soil provinces, and a wide range of geographical location. The results of petrographic examination of some of the samples are also included. Pendleton[3] describes an exhaustive study of 4 soil types, represented by 4, 3, 7, and 10 individual samples, respectively, all of them from the state of California. His comparisons are made from the viewpoints of mechanical and chemical composition, and of biological and pot-culture data. In both of these publications the general conclusion is drawn that, although there are some distinct differences between various groups when the averages are considered, it is not uncommon for the soils of a given group or type to differ from each other more than they do from those of other groups or types.

The present bulletin deals with the chemical composition of 67 soils and 64 subsoils, distributed among 8 soil series and 27 soil types, all from the state of Louisiana and all from the area known as the "Long Leaf Pine Belt." Comparison is made (a) on the basis of soil series, without regard to texture, and (b) on the basis of texture or fineness of the soil particles, without regard to series.

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[1] Submitted for publication November, 1919.

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DESCRIPTION OF SOILS

The samples were, with two exceptions, collected and classified by the late Dr. F. V. Emerson, in charge of the Louisiana State Soil Survey. In general, the depth of sampling did not coincide with the natural subsoil line, but surface samples were taken to a uniform depth of 8 inches. The subsoils were in each case (except the two referred to above) sampled at two different depths, namely from the 17th through the 23rd inch, and from the 28th through the 36th inch. For the results reported in this bulletin the two subsoil samples were not analyzed separately but were composited. A description of the soils showing classification, location, etc., follows.

1. Caddo fine sandy loam, 8 miles north of Pineville, Rapides Parish. Mound phase. 0 to (6-8) inches, dark brown sandy loam; (6-8) to 30 inches, yellowish brown sandy loam; 30 to 36 inches, yellowish clay loam. Scattering concretions in subsoil.

2. Caddo fine sandy loam, same location as No. 1. Intermound phase. 0 to (4-8) inches, black to brown loam to sandy loam; (4-8) to 36 inches, gray silty clay mottled sparingly with black and red. Black concretions abundant in subsoil.

3. Caddo fine sandy loam, Sec. 4, T. 11 N., R. 3 W., 2 miles northwest of Winnfield, Winn Parish. Mound phase. 0 to (4-6) inches, dark brown loamy sand; 6 to 36 inches, light brown to pale yellow loamy sand.

4. Caddo fine sandy loam, same location as No. 3. Intermound phase. 0 to (4-6) inches, black-brown sandy loam; (4-6) to (15-24) inches, "ashy" gray sandy loam; (15-24) to 36 inches, gray clay loam mottled with reddish brown. Very compact and tight, but so friable that it falls from auger. Almost imperviosu to water.

5. Caddo very fine sandy loam, N. W. corner of Sec. 3, T. 9 N., R. 12 W., 9 miles southwest of Sodus, Sabine Parish. Mound phase. 0 to 6 inches, dark brown very fine sandy loam or fine sand; 6 to 28 inches, yellowish fine sandy loam; 28 to 36 inches, yellowish red to light red fine sandy loam.

6. Caddo very fine sandy loam, same location as No. 5. Intermound phase. 0 to 3 inches, brown loam; 3 to 24 inches, gray silty loam; 24 to 36 inches, same with reddish mottlings.

7. Caddo silt loam, 4 miles east of Oakdale, Allen Parish. Mound phase. 0 to 4 inches, black-brown loam to sandy loam; 4 to 15 inches, light brown silt loam; 15 to 36 inches, gray silt loam to silty clay loam.

8. Caddo silt loam, same location as No. 7. Intermound phase. 0 to 4 inches, brown-black silt loam; 4 to 20 inches, moist plastic gray clay, slightly mottled with red; 20 to 36 inches, same, dry and tight.

9. Caddo silt loam, 7 miles west of Oakdale, Allen Parish. Mound phase. 0 to 6 inches, black-brown loam; 6 to 30 inches, brown silt loam; 30 to 36 inches, gray silty clay loam.

10. Caddo silt loam, same location as No. 9. Intermound phase. 0 to 4 inches, black-brown silt loam; 4 to 26 inches, gray to brown clay loam; 26 to 36 inches, tight gray clay.

11. Greenville sandy loam, 1½ miles east of Provencal, Natchitoches Parish. 0 to 8 inches, gray to gray-brown sandy loam with "ironstone" pebbles; 8 to 20 inches, dark red plastic clay; 20 to 36 inches, same with white veinings and mottlings.

12. Greenville fine sandy loam, ½ mile north of Neame, Vernon Parish. 0 to 10 inches, gray fine sandy loam; 10 to 36 inches, brick red heavy loam or sandy clay. Five percent of soil is gravelly—mostly indurated Eocene sandstone pebbles. Also some chert pebbles.

13. Greenville fine sandy loam, 4 miles north of Neame, Vernon Parish. 0 to 10 inches, gray fine sandy loam with some Eocene gravel; 10 to 36 inches, yellowish clay loam to clay, becoming mottled with drab and pink in lower section. Scattering Lafayette white chert pebbles in upper 10 inches.

14. Greenville gravelly sandy loam, Sec. 27, T. 13 N., R. 3 W., 8 miles west of Dodson, Winn Parish. 0 to 2 inches, dark brown sandy loam; 2 to 24 inches, light brown sandy loam; 24 to 36 inches, brick red gravelly clay.

15. Lufkin loam, 11 miles west of Greensburg, St. Helena Parish. 0 to 2 inches, black silt loam; 2 to (18-24) inches, light gray silt loam; 24 to 36 inches, same with red spots and concretions.

16. Lufkin loam, 1½ miles southwest of Jena, La Salle Parish. 0 to 3 inches, black-brown heavy loam; 3 to 36 inches, gray plastic clay with many black concretions.

17. Lufkin loam, 1 mile south of White Sulfur Springs, La Salle Parish. 0 to 5 inches, black-brown to grayish loam; 5 to (10-15) inches, yellowish brown clay loam; (10-15) to 36 inches, white stiff clay, abundantly mottled with cinnamon red and black, dry after heavy rain.

18. Lufkin loam, 1 mile north of Carson, Beauregard Parish. 0 to (8-12) inches, gray loam with much very fine sand; (8-12) to 36 inches, light brown clay loam, mottled with drab.

19. Lufkin sandy loam, 5 miles west of Jena, La Salle Parish. 0 to (4-6) inches, black-brown loam to heavy sandy loam; (4-6) to 36 inches, gray clay filled with concretions. Concretions up to ¾ inch in diameter.

20. Lufkin clay, 6 miles east of Oakdale, Allen Parish. 0 to 4 inches, black-brown silt loam; 4 to 36 inches, gray clay mottled with red.

21. Lufkin clay, 12½ miles west of Pitkin, Vernon Parish. 0 to 4 inches, brown-black silty clay loam; 4 to 12 inches, light brown clay loam; 12 to 36 inches, gray to drab clay mottled with brown.

22. Lufkin clay, 4 miles northwest of Natchitoches, Natchitoches Parish. 0 to (2-5) inches, black-brown clay loam to loam; (2-5) to (10-20) inches, light yellow clay loam, friable when wet; (12-24) to 36 inches, drab clay mottled with yellow and red.

23. Lufkin clay loam, ½ mile south of Bon Ami, Beauregard Parish. 0 to 10 inches, gray clay loam; 10 to 36 inches, gray clay well mottled with brown. (The subsoil was not analyzed.)

24. Monroe silt loam, 13 miles west of Franklinton, Washington Parish.

25. Monroe silt loam, 11 miles west of Franklinton, Washington Parish.

26. Monroe silt loam, 2 miles southeast of Kentwood on Bailey Road, Tangipahoa Parish. 0 to (3-10) inches, very dark brown sandy silty loam; (3-10) to 30 inches, brown to yellowish brown silty loam to sandy clay; 30 to 36 inches, brick red sandy clay.

27. Monroe silt loam, 4 miles southeast of Kentwood, on

Bailey Road, Tangipahoa Parish. 0 to (4-8) inches, brown fine sandy loam; (4-8) to 36 inches, yellowish stiff silty clay loam.

28. Monroe silt loam, 7 miles southeast of Kentwood, on Bailey Road, Tangipahoa Parish. 0 to (4-8) inches, dark brown silt loam; (4-8) to 36 inches, brick red clay with scattering small chert pebbles.

29. Monroe silt loam, 1 mile south of Greensburg, St. Helena Parish. 0 to (2-4) inches, black to brown silt loam; (2-4) to 8 inches, light brown silt loam; 8 to 36 inches, light brown silty clay loam.

30. Monroe silt loam, 2 miles south of Greensburg, St. Helena Parish. 0 to (2-4) inches, black-brown silt loam to loam; (2-4) to 20 inches, light brown silty clay loam, plastic; 20 to 36 inches, same with gray mottling, friable and dry. Four feet below surface is purplish red clay seamed with white streaks.

31. Norfolk sand, 10½ miles west of Leesville, Vernon Parish. 0 to (8-20) inches, gray sand to loamy sand; (8-20) to 36 inches, pale yellow sand.

32. Norfolk sandy loam, 2½ miles northwest of Natchitoches, Natchitoches Parish. 0 to 2 inches, black-brown sandy loam; 2 to 36 inches, light brown sandy loam to loamy sand.

33. Norfolk sandy loam, 9 miles south-southwest of Leesville, Vernon Parish. 0 to (6-8) inches, dark brown sand; (6-8) to 26 inches, light brown sandy loam; 26 to 36 inches, brown loamy sand.

34. Norfolk loamy sand, 5 miles east of Pitkin, Vernon Parish. 0 to 4 inches, black-brown loamy sand; 4 to 11 inches, yellowish brown sandy loam; 11 to 36 inches, yellowish sandy clay.

35. Orangeburg sand, 1 mile east of Pitkin, Vernon Parish. 0 to 4 inches, black-brown loamy sand; 4 to 36 inches, brick red very sandy clay.

36. Orangeburg sand, 11 miles east of Jena, La Salle Parish. 0 to (6-12) inches, light brown sand to loamy sand; (6-12) to 36 inches, brick red sandy clay. Sharp contrast between sand and sandy clay. Very gravelly.

37. Orangeburg sandy loam, 5¼ miles west of Greensburg, St. Helena Parish. 0 to (3-6) inches, black loam to loamy sand;

6 to (22-28) inches, light brown silty clay loam; 28 to 36 inches, red sandy clay. Ferruginous sandstone pebbles abundant.

38. Orangeburg sandy loam, 9 miles northeast of Colfax, Grant Parish. 0 to (2-4) inches, black-brown sandy loam; (2-4) to (8-10) inches, light brown loam; (8-10) to 36 inches, brick red, compact sandy clay.

39. Orangeburg fine sandy loam, 16 miles north of Franklinton, Washington Parish. 0 to (2-3) inches, black to brown sandy loam; 3 to 8 inches, yellowish brown sandy loam; 8 to 36 inches, brick red sandy clay.

40. Orangeburg fine sandy loam, 2 miles west of Kentwood, Tangipahoa Parish. 0 to (6-8) inches, black sandy loam; (6-8) to 36 inches, sandy clay, mostly brick red mottled with pink and gray.

41. Orangeburg fine sandy loam, 8 miles west of Kentwood, Tangipahoa Parish. 0 to (3-6) inches, black sandy loam; (3-6) to 36 inches, brick red sandy clay, heavier with depth.

42. Orangeburg fine sandy loam, 2½ miles west of Greensburg, St. Helena Parish. Typical.

43. Orangeburg fine sandy loam, 3½ miles north of Pineville, Rapides Parish.

44. Orangeburg fine sandy loam, 15½ miles west of Leesville, Vernon Parish. 0 to (8-16) inches, gray fine sandy loam; (8-16) to 36 inches, red sandy clay.

45. Orangeburg fine sandy loam, 8 miles west of Leesville, Vernon Parish. 0 to 10 inches, gray fine sandy loam; 10 to 36 inches, reddish clay mottled with drab; some sand.

46. Orangeburg fine sandy loam, 8 miles east of Leesville, Vernon Parish. 0 to 8 inches, dark brown fine sandy loam; 8 to 36 inches, yellowish brown sandy clay.

47. Orangeburg fine sandy loam, 16 miles east of Leesville, Vernon Parish. 0 to 8 inches, gray fine sandy loam; 8 to 36 inches, brick red sandy clay.

48. Orangeburg loamy sandy, 8 miles west of Franklinton, Washington Parish.

49. Orangeburg loamy sand, 5½ miles northwest of Natchitoches, Natchitoches Parish. 0 to 4 inches, dark brown loamy sand; 4 to (6-10) inches, light brown loamy sand; (6-10) to 24

inches, brick red tight clay; 24 to 36 inches, same, mottled with drab and red.

50. Ruston loam, 2 miles northeast of Jena, La Salle Parish. 0 to (4-6) inches, dark brown heavy loam; (4-6) to 24 inches, tan colored clay loam; 24 to 36 inches, gray clay much mottled with red and brown.

51. Ruston loam, 6 miles north of Dry Prong, Grant Parish. 0 to (6-10) inches, black-brown loam; (6-10) to 36 inches, yellow-brown loam to sandy clay.

52. Ruston sandy loam, 11 miles northeast of Colfax, Grant Parish. 0 to (2-6) inches, black-brown sandy loam; 6 to 36 inches, light brown sandy clay, sand prominent.

53. Ruston sandy loam, 10 miles north of Pineville, Rapides Parish. 0 to 2 inches, dark brown sandy loam; 2 to (6-10) inches, yellowish sandy loam; (6-10) to (15-25) inches, cinnamon red plastic clay; (15-25) to 36 inches, white-gray gritty clay. Probably derived from Eocene. Scattering pebbles, probably from formerly overlying Lafayette material.

54. Ruston fine sandy loam, 10 miles south of DeRidder, Beauregard Parish. 0 to (8-18) inches, gray fine sandy loam; (8-18) to 36 inches, brown to dark brown sandy loam to sandy clay. Scattering chert gravel in places.

55. Ruston very fine sandy loam, 4 miles northwest of Bush, St. Tammany Parish. Light gray soil; reddish yellow subsoil. Soil and subsoil were not sampled separately but a composite sample 14 inches deep was taken.

56. Ruston very fine sandy loam, near Central School, 20 miles northeast of Covington, St. Tammany Parish. 0 to 4½ inches, dark sandy loam; 4½ to 11 inches, light yellow clay. The depths indicated were those sampled for soil and subsoil, respectively.

57. Susquehanna loam, 1 mile east of Provencal, Natchitoches Parish. 0 to (4-8) inches, sandy loam to loam; (4-8) to 36 inches, dark red plastic clay.

58. Susquehanna loam, 5 miles southeast of Natchitoches, on Model Road, Natchitoches Parish. 0 to (2-4) inches, dark brown loam; (2-4) to (10-20) inches, dark red plastic clay; (10-20) to 36 inches, dark red plastic clay.

59. Susquehanna fine sandy loam, 1½ miles west of Pitkin,

Vernon Parish. 0 to 4 inches, black-brown fine sandy loam; 4 to (8-12) inches, yellowish brown clay loam; (8-12) to 36 inches, drab clay with scarlet mottling.

60. Susquehanna fine sandy loam, Sec. 35, R. 3 W., T. 11 N., 2½ miles south of Winnfield, Winn Parish. 0 to 2 inches, dark brown sandy loam; 2 to 8 inches, yellowish brown clay loam; 8 to 36 inches, pale yellow to light brown plastic clay.

61. Susquehanna fine sandy loam, Sec. 26, R. 3 W., T 10 N., 9 miles south of Winnfield, Winn Parish. 0 to (1-3) inches, brown-black loamy sand; 3 to (13-17) inches, pale yellow to light brown sandy loam to loamy sand; (13-17) to 36 inches, stiff clay mottled with drab and cinnamon red.

62. Susquehanna fine sandy loam, Sec. 12, T. 11 N., R. 4 W., 4 miles southeast of Calvin, Winn Parish. 0 to 2 inches, dark brown loamy sand; 2 to (10-15) inches, light yellowish brown loamy sand; (10-15) to 36 inches, cinnamon red clay or clay loam, jointed, plastic.

63. Susquehanna very fine sandy loam, N. E. quarter of Sec. 2, T. 7, R. 3 W., near Colfax, Grant Parish. Red sandy loam soil with red clay subsoil. (Subsoil not analyzed.)

64. Susquehanna clay, Sec. 11, T. 11 N., R. 4 W., 3 miles southeast of Calvin, Winn Parish.

65. Susquehanna clay, 3½ miles south of Calvin, Winn Parish. Typical except that gravelly subsoil is found at 24 to 32 inches.

66. Susquehanna clay, Sec. 28, T. 13 N., R. 3 W., 1½ miles northwest of Dodson, Winn Parish. Typical.

67. Susquehanna gravelly clay loam, S. E. quarter of Sec. 8, T. 9 N., R. 12 W., 6½ miles southwest of Sodus, Sabine Parish. 0 to 6 inches, brown gravelly fine sandy loam; 6 to 36 inches, brick red stiff clay.

METHODS OF ANALYSIS

The soils were prepared for analysis by air-drying and passing through a 2-millimeter sieve. A sub-portion was prepared for determination of total constituents by grinding in an agate mortar until it passed a 100-mesh sieve.

Total nitrogen was determined by the usual Kjeldahl method.

Total phosphorus was determined volumetrically, solution being obtained by the magnesium nitrate method. Total potassium, calcium, and magnesium were in a few cases determined in the solution obtained by decomposition with hydrofluoric acid; but in most cases the J. Lawrence Smith fusion method was used for potassium and the calcium-magnesium solution was obtained by decomposition with sodium peroxide.

Lime requirement was determined by the Veitch method, using air-dry 2-millimeter soil.

RESULTS OF ANALYSES

Table 1 gives the results of the analyses in detail. All results, except for lime requirement, are calculated to oven-dry soil.

TABLE 1

Chemical Analyses of Certain Louisiana Soils. Soils and Subsoils Shown Separately.

Series and Type	Soil Number	Nitrogen		Phosphorus		Potassium		Calcium		Magnesium		Lime Req.	
		Soil	Subsoil	Soil	Subsoil	Soil	Subsoil	Soil	Subsoil	Soil	Subsoil	Soil	Subsoil
		%	%	%	%	%	%	%	%	%	%	%	%
Caddo—													
Fine sandy loam	1	.045	.020	.011	.013	.338	.354	.034	.051	.030	.081	.010	.020
Fine sandy loam	2	.049	.021	.015	.012	.373	.421	.071	.056	.023	.106	.030	.110
Fine sandy loam	3	.049	.023	.016	.015	.270	.277	.037	.043	.002	.015	.070	.040
Fine sandy loam	4	.057	.020	.014	.015	.289	.296	.063	.042	.006	.015	.100	.060
Very fine sandy loam	5	.055	.019	.016	.011	.447	.560	.180	.155	.035	.057	.035	.035
Very fine sandy loam	6	.049	.011	.013	.013	.544	.708	.166	.145	.131	.218	.060	.100
Silt loam	7	.036	.020	.012	.015	.312	.380	.170	.126	.013	.029	.025	.025
Silt loam	8	.056	.023	.014	.011	.405	.419	.117	.085	.031	.109	.040	.060
Silt loam	9	.109	.027	.018	.013	.121	.164	.127	.010	.002	.061	.070	.060
Silt loam	10	.091	.032	.014	.012	.132	.257	.025	.018	.058	.061	.080	.075
Greenville—													
Sandy loam	11	.041	.039	.012	.007	.422	.740	.134	.074	.047	.283	.040	.100
Fine sandy loam	12	.058	.024	.012	.017	.142	.199	.067	.032	.016	.074	.040	.050
Fine sandy loam	13	.034	.021	.011	.010	.138	.177	.029	.010	.007	.088	.030	.080

Gravelly sandy loam	14	.064	.034	.019	.020	.367	.572	.086	.040	.034	.188	.020	.110
Lufkin—													
Loam	15	.037	.019	.014	.020	.631	.933	.190	.203	.144	.247	.040	.090
Loam	16	.046	.025	.013	.012	.807	.843	.121	.101	.075	.147	.055	.060
Loam	17	.051	.027	.020	.009	.637	.704	.072	.040	.073	.139	.050	.070
Loam	18	.045	.014	.013	.007	.138	.180	.031	.034	.027	.044	.060	.050
Sandy loam	19	.073	.042	.013	.011	1.004	1.200	.127	.109	.104	.263	.050	.040
Clay	20	.045	.026	.016	.016	.261	.572	.186	.167	.050	.306	.040	.070
Clay	21	.037	.023	.012	.013	.389	.470	.045	.013	.103	.189	.060	.100
Clay	22	.057	.031	.013	.011	.483	.553	.084	.064	.091	.160	.045	.080
Clay loam	23	.001	...	.012	...	.158	...	.018	...	.038	...	.055	...
Monroe—													
Silt loam	24	.066	.025	.076	.030	.618	.676	.277	.164	.096	.181	.060	.075
Silt loam	25	.061	.029	.014	.011	.563	.624	.173	.257	.107	.328	.065	.080
Silt loam	26	.048	.022	.014	.014	.705	.682	.245	.223	.120	.247	.045	.070
Silt loam	27	.053	.021	.017	.015	.550	.473	.210	.177	.076	.190	.065	.075
Silt loam	28	.038	.021	.017	.025	.379	.389	.188	.179	.074	.183	.040	.080
Silt loam	29	.046	.007	.015	.016	.608	.370	.192	.115	.096	.135	.060	.070
Silt loam	30	.030	.025	.019	.022	.505	.460	.089	.059	.050	.109	.060	.070
Norfolk—													
Sand	31	.021	.010	008	.010	.206	.167	.029	.016	.010	.004	.025	.020
Sandy loam	32	.045	.022	.013	.013	.647	.627	.080	.082	.086	.083	.040	.020
Sandy loam	33	.023	.011	.013	.013	.225	.251	.031	.020	.010	.016	.020	.010
Loamy sand	34	.034	.016	.011	.014	.148	.312	.034	.031	.024	.120	.025	.040
Orangeburg—													
Sand	35	.067	.018	.017	.016	.383	.425	.178	.024	.039	.094	.045	.025
Sand	36	.054	.019	.019	.014	.846	.981	.095	.047	.026	.127	.060	.080

Continued on next page.

TABLE 1—(Continued)

Series and Type	Soil Number	Nitrogen		Phosphorus		Potassium		Calcium		Magnesium		Lime Req.	
		Soil	Subsoil	Soil	Subsoil	Soil	Subsoil	Soil	Subsoil	Soil	Subsoil	Soil	Subsoil
Sandy loam	37	.056	.025	.016	.017	.685	.666	.215	.096	.144	.321	.060	.050
Sandy loam	38	.028	.021	.009	.009	.553	.653	.058	.061	.058	.172	.030	.050
Fine sandy loam	39	.059	.028	.020	.054	.418	.395	.300	.283	.120	.221	.070	.060
Fine sandy loam	40	.043	.016	.019	.015	.624	.428	.218	.101	.082	.354	.030	.070
Fine sandy loam	41	.036	.022	.011	.024	.518	.572	.175	.124	.118	.242	.060	.080
Fine sandy loam	42	.051	.018	.020	.019	.624	.450	.173	.096	.207	.203	.060	.070
Fine sandy loam	43	.027	.021	.011	.016	.476	.653	.039	.049	.035	.143	.030	.060
Fine sandy loam	44	.033	.030	.010	.010	.196	.283	.030	.028	*	.142	.030	.080
Fine sandy loam	45	.039	.025	.013	.010	.466	.647	.052	.022	.004	.093	.030	.070
Fine sandy loam	46	.032	.008	.013	.017	.370	.405	.039	.074	.013	.131	.025	.055
Fine sandy loam	47	.031	.017	.011	.011	.141	.293	.055	.042	.016	.083	.040	.045
Loamy sand	48	.053	.023	.023	.015	.399	.508	.244	.254	.114	.188	.065	.040
Loamy sand	49	.046	.025	.011	.012	.634	.614	.076	.073	.046	.240	.020	.085
Ruston—													
Loam	50	.073	.030	.014	.014	1.030	1.210	.099	.081	.119	.256	.055	.070
Loam	51	.053	.023	.012	.009	.296	.320	.079	.051	.040	.077	.065	.070
Sandy loam	52	.032	.022	.022	.009	.431	.579	.064	.041	.036	.080	.040	.060
Sandy loam	53	.034	.012	.013	.011	.347	.847	.061	.099	.048	.326	.035	.120

Fine sandy loam	54	.042	.011	.017	.014	.175	.203	.035	.026	.026	.079	.055	.060
Very fine sandy loam	55	.053	...	[illegible]	...	.2 0	...	.047	...	.057	...	.035	...
Very fine sandy loam	56	.083	.033	.012	.009	.219	.232	.059	.034	.052	.079	.070	.035
Susquehanna—													
Loam	57	.055	.028	010	.013	.412	.714	.118	.080	.053	.242	.040	.070
Loam	58	.061	.045	.024	.025	.595	1.383	.117	.049	.220	.702	.045	.120
Fine sandy loam	59	.046	.019	.014	.014	.312	.373	.196	.016	.057	.159	.045	.070
Fine sandy loam	60	.042	.025	.011	.010	.631	.656	.085	.050	.120	.215	.075	.180
Fine sandy loam	61	.037	.028	.014	.014	.946	.865	.170	.056	.103	.198	.070	.155
Fine sandy loam	62	.035	.025	.014	.023	.370	.572	.027	.043	.030	.182	.040	.110
Very fine sandy loam	63	.030	...	.084	...	.463	...	.138	...	.062	...	.020	...
Clay	64	.044	.031	.028	.022	.351	.460	.071	.098	.137	.299	.090	.170
Clay	65	.077	.039	.029	.031	.344	.431	.090	.071	.084	.193	.080	.140
Clay	66	.072	.038	.032	.027	.556	.791	.147	.113	.219	.425	.100	.250
Gravelly clay loam	67	.085	.029	.024	.031	.360	.956	.232	.153	.068	.341	.030	.200

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*Trace.

COMPARISON ON BASIS OF SOIL SERIES

In Table 2 the analyses have been grouped on the basis of soil series. For each series there are shown the number of samples analyzed and the highest, lowest, and average values found for each constituent. Also at the end of the table there are shown corresponding figures for the entire group of soils. The average for each series, in the case of potassium, calcium, and magnesium, is shown graphically in Figures 1 and 2, the abscissae representing soil series and the ordinates representing percentages of the various constituents. Figure 1 (a) compares the potassium, calcium, and magnesium contents of the soils; Figure 1 (b) those of the subsoils. Figure 2, on the other hand, makes direct comparison of soil and subsoil with respect to (a) potassium, (b) calcium, and (c) magnesium.

A. Maximum, Minimum, and Average.

The variation between high and low is quite large in all cases, but the averages are remarkably uniform in some cases. This is particularly true of nitrogen and phosphorus. In fact, the averages for these elements within each soil series do not, as a rule, differ from the grand averages of all the soils by an amount greater than the experimental error. For all practical purposes it may be said that these soils are uniform and very low both in nitrogen and in phosphorus. The same thing is even more true of the subsoils.

Although these soils are without exception acid, the lime requirement is not over one ton of calcium oxide per acre (assuming two million pounds of soil to the acre) in any case and the general average is only one-half ton. Even in the subsoil the highest value found for lime requirement is only two and one-half tons of calcium oxide per two million pounds. The Norfolk series runs consistently lower than the average in both soil and subsoil; the Greenville soil is much like the Norfolk in this respect, but the subsoil runs decidedly higher.

The highest value found for potassium is 1.383% in one of the Susquehanna subsoils, and the lowest is 0.121% in one of the Caddo soils. Even wider variations occur in the figures for calcium and magnesium. Moreover, these wide variations occur to a greater or less extent within each individual soil series. This fact brings out very forcibly the following two points:

TABLE 2

Highest, Lowest, and Average Percentage of Each Constituent in Each Soil Series. Soils and Subsoils Shown Separately.

Series	No. of Analyses	Nitrogen			Phosphorus			Potassium			Calcium			Magnesium			Lime Req.		
		High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Orangeburg—																			
Soil	15	.067	.027	.044	.023	.009	.015	.846	.141	.489	.300	.030	.130	.207	*	.068	.070	.020	.044
Subsoil	15	.030	.008	.021	.054	.009	.017	.981	.283	.531	.283	.022	.092	.354	.094	.184	.085	.025	.061
Norfolk—																			
Soil	4	.045	.021	.031	.013	.008	.011	.647	.148	.306	.080	.029	.044	.086	.010	.032	.040	.020	.028
Subsoil	4	.022	.010	.015	.014	.010	.012	.627	.167	.339	.082	.016	.037	.120	.004	.056	.040	.010	.022
Ruston—																			
Soil	7	.083	.032	.053	.022	.012	.015	1.030	.175	.395	.099	.035	.063	.119	.026	.054	.070	.035	.051
Subsoil	6	.033	.011	.022	.014	.009	.011	1.210	.203	.565	.069	.026	.055	.326	.077	.149	.120	.035	.069
Lufkin—																			
Soil	9	.073	.001	.044	.020	.012	.014	1.004	.138	.501	.190	.018	.097	.144	.050	.078	.060	.040	.051
Subsoil	8	.042	.014	.026	.020	.007	.012	1.200	.180	.682	.203	.013	.091	.306	.044	.187	.100	.040	.070
Greenville—																			
Soil	4	.064	.034	.049	.019	.011	.014	.422	.138	.267	.134	.029	.079	.047	.007	.026	.040	.020	.032
Subsoil	4	.039	.021	.029	.020	.007	.013	.740	.177	.422	.074	.010	.039	.283	.074	.158	.110	.050	.085
Susquehanna—																			
Soil	11	.085	.030	.053	.084	.010	.026	.946	.312	.485	.232	.027	.126	.220	.030	.105	.100	.020	.058
Subsoil	10	.045	.019	.031	.031	.010	.021	1.383	.373	.720	.153	.016	.073	.702	.182	.296	.250	.070	.146
Monroe—																			
Soil	7	.066	.030	.049	.076	.014	.025	.705	.379	.561	.277	.089	.196	.107	.050	.088	.065	.040	.056
Subsoil	7	.029	.007	.021	.030	.011	.019	.682	.370	.525	.257	.059	.168	.328	.109	.196	.080	.070	.074
Caddo—																			
Soil	10	.109	.036	.060	.018	.011	.014	.544	.121	.323	.180	.025	.099	.131	.002	.033	.100	.010	.052
Subsoil	10	.032	.011	.022	.015	.011	.013	.708	.164	.384	.155	.010	.073	.218	.015	.075	.110	.020	.058
All—																			
Soil	67	.109	.001	.049	.084	.008	.017	1.030	.121	.439	.300	.018	.112	.220	*	.066	.100	.010	.049
Subsoil	64	.045	.007	.024	.054	.007	.015	1.383	.164	.540	.283	.010	.084	.702	.004	.174	.250	.010	.076

*Trace.

1. There is no such thing as *absolute* uniformity or even similarity within any of the series.

2. A correct knowledge of the *tendency* of any series toward uniformity cannot be gained by a consideration of averages (such as are shown in Table 2) because these averages are greatly influenced by any abnormal values, either high or low.

In order to overcome the difficulties just mentioned it is necessary to study the individual analyses as shown in Table 1.

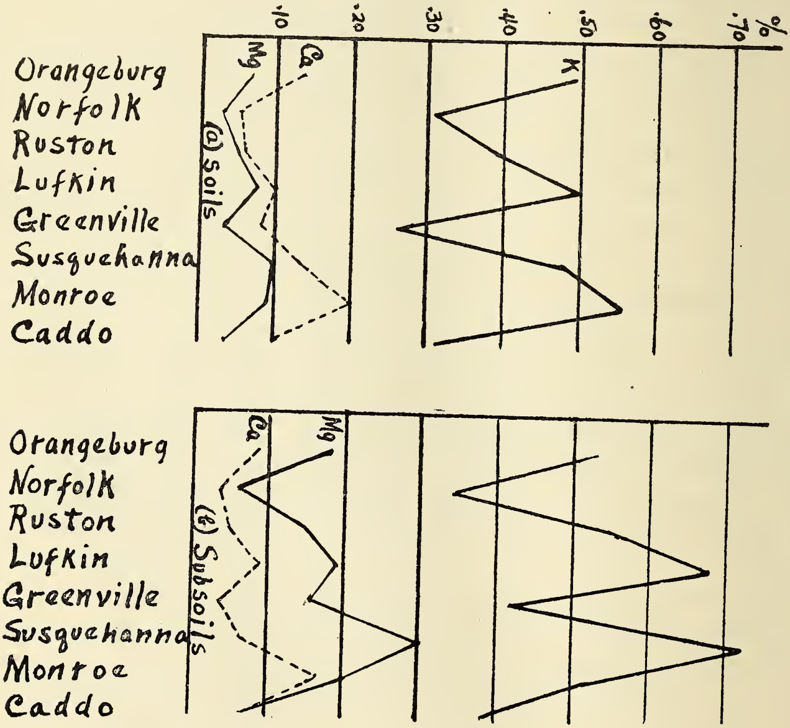

FIGURE 1.
Relation of Potassium, Calcium, and Magnesium to each other in each soil series. (a) Soils. (b) Subsoils.

Such a study shows that the percentage of potassium is very irregular, though with a tendency to run lower in the soils of the Norfolk, Ruston, Greenville, Susquehanna, and Caddo series than in the others. In the subsoils this tendency is seen with the Norfolk, Ruston, and Caddo series only.

The percentage of calcium is also decidedly irregular except in the Norfolk, Ruston, and Greenville soils, where it is uniformly low. On the other hand, it is relatively high, though irregular, in the Monroe silt loam. These same remarks apply to the subsoils, with the addition of Susquehanna to the list of those running uniformly low and with the omission of Monroe silt loam, which is not uniformly high in its subsoil calcium content.

The magnesium content is somewhat more regular than that of calcium so far as the soils are concerned, but in the subsoils it is decidedly irregular. In the soils of the Norfolk, Ruston, Greenville, and Caddo series the magnesium content is quite uniform and distinctly lower than in the Lufkin, Susquehanna, and Monroe series. In the Orangeburg series the values are about equally divided between high and low. In the subsoils there appears to be no generalization possible regarding magnesium content as between series, except that it runs fairly uniform and low in the Caddo and Norfolk series.

B. Relation of Various Constituents to Each Other.

Figure 1 (a) shows the relation of average potassium, calcium, and magnesium percentages to one another in the soils. This graph indicates that the potassium content is consistently very much higher than that of calcium or magnesium. The Orangeburg, Lufkin, Susquehanna, and Monroe soils show the highest potassium content, while the Greenville runs lowest of all in this constituent.

The shape of the calcium curve is very similar to that for potassium. The magnesium and calcium curves parallel one another still more closely, the magnesium being consistently lower. Calcium and magnesium are especially close in the Norfolk, Ruston, Lufkin, and Susquehanna series, but are quite high and divergent in the Monroe soil. Also the potassium in the Monroe soil averages higher than in any of the other series.

The above observations, with some exceptions, are borne out by a consideration of the individual analyses (Table 1). These show that the potassium content occasionally (soils No. 1, 12, and 47) drops down to the level of the calcium; that high potassium is not always accompanied by high calcium and magnesium, but frequently quite the reverse; that the calcium is consistently higher than the magnesium in the Greenville, Monroe, and Caddo soils, but often drops below it in the others.

When the constituents of the subsoil are compared (Figure 1 (b)) it is found that here again the potassium runs much higher than either calcium or magnesium, and that the three curves are very similar in general shape. In fact, the magnesium curve is almost a duplicate of that for potassium. But the subsoil exhibits a striking difference from the soil in that the magnesium runs decidedly higher than the calcium in nearly all cases. Outside of the Caddo series, where the subsoil calcium and magnesium average the same, there are only two instances (soils No. 39 and 48) where the subsoil calcium exceeds the magnesium. It is interesting to note that the Monroe series, which shows wide divergence between calcium and magnesium in the soil, is one of those showing the least divergence between these

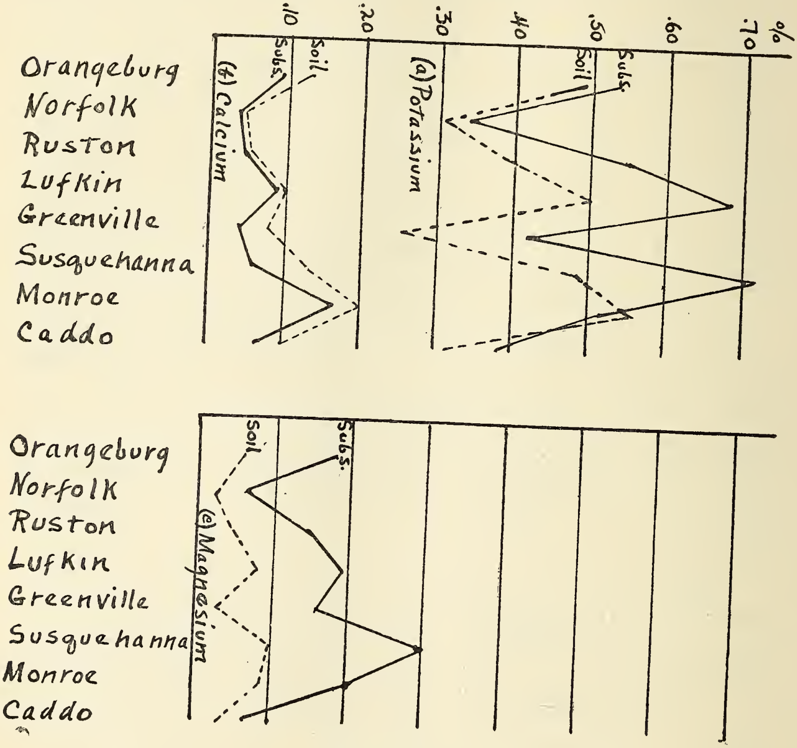

FIGURE 2.

Relation of soil to subsoil in each soil series with respect to (a) Potassium, (b) Calcium, and (c) Magnesium.

constituents in the subsoil. On the other hand, the Susquehanna series, which shows only a small divergence in the soil, shows the greatest divergence of any in the subsoil. However, attention should be called to the fact that the high value for magnesium in Susquehanna subsoils is largely influenced by the abnormality of a single sample, No. 58. This serves to emphasize the point previously made, that the average figures may be misleading unless they are supplemented by reference to the individual analyses.

C. Relation of Soil to Subsoil.

As already stated, the nitrogen is fairly uniform in all of the soils analyzed. There is roughly twice as much nitrogen in the soil as in the subsoil.

The phosphorus is extremely low and is about equally distributed between soil and subsoil.

Figure 2 (a) shows that the potassium content of the subsoils averages higher than that of the soils in every case except one—the Monroe silt loam—in which it is slightly lower. In the Orangeburg, Norfolk, Monroe, and Caddo series there is very little difference in potassium content between soil and subsoil, whereas in the Ruston, Lufkin, Greenville, and Susquehanna series there appears to be a decided difference. But an examination of the detailed figures in Table 1 shows that even in these series there are more cases of close agreement than of divergence between soil and subsoil, and that the high averages are due to a few subsoils with abnormally high potassium content.

Similarly it is shown by Figure 2 (b) that calcium averages higher in the soil than in the subsoil, there being a wider divergence in the case of Susquehanna than in any of the others. Reference to Table 1 verifies this conclusion, but shows that even in the Susquehanna series there are some cases where the subsoil calcium equals or exceeds that in the soil.

The magnesium, like potassium but unlike calcium, runs higher in the subsoil than in the soil, as will be seen by reference to Figure 2 (c). Moreover, the divergence between soil and subsoil is much greater in respect to magnesium than it is in respect to calcium. Only in two series—the Norfolk and Caddo—does the quantity of magnesium in the soil approach that in the subsoil.

There appears to be a very close and striking correlation between potassium and magnesium, at least in so far as series averages are concerned. Attention has already been called to the fact that in both soil and subsoil—Figures 1 (a) and 1 (b)—the magnesium graph closely parallels that of potassium. It will now be seen, by reference to Figures 2 (a) and 2 (c), that the relation of soil to subsoil with respect to magnesium is much the same as it is with respect to potassium.

Mention has already been made of the fact that the lime requirement of these soils is uniformly low. It is only slightly higher in the subsoils, and does not differ essentially from one series to another.

COMPARISON ON BASIS OF TEXTURE

In the preceding discussion each soil series, including, as a rule, soils of various textures, has been taken as a unit and the attempt has been made to find points of similarity or difference between the several series. Another possible basis for comparison is the degree of fineness, or texture, of the soil. In Table 3 the soils have been grouped into eight classes, beginning with the coarsest and ending with the finest, as follows:

Class A. Sand.
" B. Loamy sand.
" C. Sandy loam and gravelly sandy loam.
" D. Fine sandy loam and very fine sandy loam.
" E. Loam.
" F. Silt loam.
" G. Clay loam and gravelly clay loam.
" H. Clay.

The subsoils are grouped along with their respective soils, though it might be more logical to arrange them according to subsoil texture.

Table 3 is similar to Table 2 except that the units are classes as above defined instead of the customary series.

The averages shown in Table 3 are plotted graphically in Figures 3 and 4. These are similar to Figures 1 and 2 except that the units are the above described classes instead of series. The ordinates show the average percentages of potassium, calcium, and magnesium, and the abscissae show the soil texture classes arranged from left to right in the order of coarse to fine.

TABLE 3.

Highest, Lowest, and Average Percentage of Each Constituent in Each Texture Class. Soils and Subsoils Shown Separately.

Class	No. of Analyses	Nitrogen			Phosphorus			Potassium			Calcium			Magnesium			Lime Req.		
		High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
A																			
Soil	3	.067	.021	.047	.019	.008	.015	.846	.206	.478	.178	.029	.101	.039	.010	.025	.060	.025	.043
Subsoil	3	.019	.010	.016	.016	.010	.013	.981	.167	.524	.047	.016	.029	.127	.004	.075	.080	.020	.042
B																			
Soil	3	.053	.034	.044	.023	.011	.015	.634	.148	.394	.244	.034	.118	.114	.024	.061	.065	.020	.037
Subsoil	3	.025	.016	.021	.015	.012	.014	.614	.312	.478	.254	.031	.119	.240	.120	.183	.085	.040	.055
C																			
Soil	9	.073	.023	.044	.022	.012	.014	1.004	.225	.520	.215	.031	.095	.144	.010	.063	.060	.020	.037
Subsoil	9	.042	.011	.025	.020	.007	.012	1.200	.251	.682	.109	.020	.069	.326	.016	.192	.120	.010	.062
D																			
Soil	25	.059	.027	.045	.084	.010	.017	.946	.138	.390	.300	.027	.099	.207	*	.054	.100	.010	.046
Subsoil	23	.033	.008	.021	.054	.009	.016	.865	.177	.436	.283	.010	.069	.354	.015	.138	.180	.020	.074
E																			
Soil	8	.073	.037	.053	.024	.010	.015	1.030	.138	.568	.190	.031	.103	.220	.027	.094	.065	.040	.051
Subsoil	8	.045	.014	.026	.025	.007	.014	1.383	.180	.786	.203	.034	.080	.702	.077	.232	.120	.050	.075
F																			
Soil	11	.109	.030	.058	.019	.012	.021	.705	.121	.445	.277	.025	.165	.120	.002	.066	.080	.025	.055
Subsoil	11	.032	.007	.023	.030	.011	.017	.682	.164	.445	.257	.010	.128	.328	.061	.148	.080	.025	.067
G																			
Soil	2	.085	.001	.043	.024	.012	.018	.360	.158	.259	.232	.018	.125	.068	.038	.053	.055	.030	.042
Subsoil	1	.029	.029	.029	.031	.031	.031	.956	.956	.956	.153	.153	.153	.341	.341	.341	.200	.200	.200
H																			
Soil	6	.077	.037	.055	.032	.012	.022	.556	.261	.397	.186	.045	.104	.219	.050	.114	.100	.040	.069
Subsoil	6	.039	.023	.031	.031	.011	.020	.791	.431	.546	.167	.013	.088	.425	.160	.262	.250	.070	.135
All																			
Soil	67	.109	.001	.049	.084	.008	.017	1.030	.121	.439	.300	.018	.112	.220	*	.066	.100	.010	.049
Subsoil	64	.045	.007	.024	.054	.007	.015	1.383	.164	.540	.283	.010	.084	.702	.004	.174	.250	.010	.076

*Trace.

A. Maximum, Minimum, and Average.

It has already been seen in Table 2 that the nitrogen and phosphorus, although exhibiting rather wide variations between extremes, are so uniform for most of the soils that the averages for each series are practically the same. This is even more true when the soils are arranged on the basis of texture (Table 3).

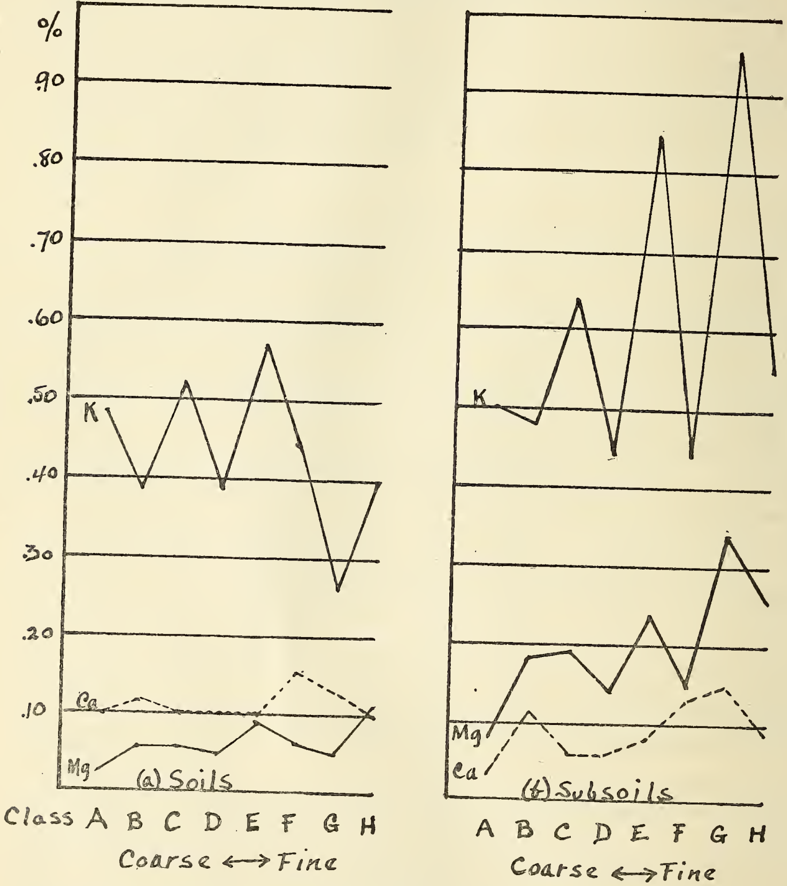

FIGURE 3.
Relation of Potassium, Calcium, and Magnesium to each other in each texture class. (a) Soils. (b) Subsoils. (Classes arranged from left to right in order of coarse to fine.)

In the case of potassium class G has much the lowest average in the soil, and, on the other hand, has the highest average in the subsoil, of any of the groups. However, since class G is represented by only two soils and one subsoil, it probably should not be given much consideration. In general, the curve for potassium both in soil and subsoil—Figures 3 (a) and 3 (b)—do not show any consistent rise or fall from left to right, especially if class G is eliminated as suggested above.

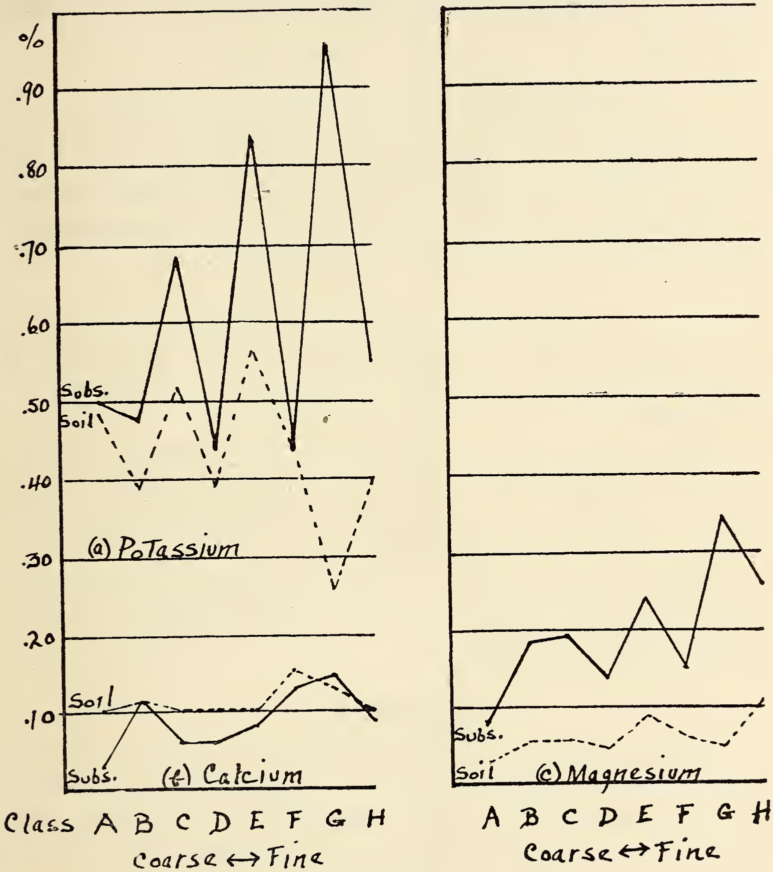

FIGURE 4

Relation of soil to subsoil in each texture class with respect to (a) Potassium, (b) Calcium, and (c) Magnesium. (Classes arranged from left to right in order of coarse to fine.)

Calcium in the soil shows a slight but inconsistent tendency to rise in passing from the coarse to the finer textured soils. In the subsoil this tendency is more pronounced.

The curve for soil magnesium has a pronounced upward trend from left to right and in the subsoil this tendency is very strong.

But here again the single abnormal subsoil of class G plays a leading part.

Lime requirement in the surface soil does not show any marked variation between the classes, but in the subsoil it shows a tendency to rise with increasing fineness of texture of the overlying soil.

B. Relation of Constituents to Each Other.

In the soil there is a noticeable resemblance, and in the subsoil a pronounced resemblance between the shapes of the potassium and magnesium curves. The calcium curve does not bear any resemblance to the others. Calcium is higher than magnesium in the soil, but decidedly lower in the subsoil.

C. Relation of Soil to Subsoil.

Potassium averages about the same for soil and subsoil in classes A, D, and F, but in the other classes it is much higher in the subsoil.

There is little difference between soil and subsoil as regards calcium in classes B, E, F, G, H, and only a slightly greater variation in the other three classes, the difference being practically always in favor of the soil.

Magnesium in the subsoil is decidedly higher than in the soil, and, if class G is omitted, the two curves—Figure 4 (c)—are almost identical in shape.

SUMMARY

Chemical analyses of a large number of soils and subsoils from a limited geographical area are presented and discussed with the purpose of discovering similarities or differences which may exist between soil series and also between classes of soils grouped on the basis of texture.

In agreement with the conclusions of other investigators, it is found that there are usually wider variations within a given series or class than there are between the averages of series or classes.

In general, these analyses indicate that chemical composition bears a closer relationship to a series system of grouping than to a system based on the soil texture only; in other words, that the derivation and general physical properties of a soil are safer criteria for judging the soil's composition than is the degree of fineness.

Some interesting relationships between the various soil constituents and between soil and subsoil are indicated.

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EGGPLANT BLIGHT

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EGGPLANT BLIGHT.

C. W. Edgerton and C. C. Moreland

The eggplant has long been a popular vegetable in the southern states. It grows very rapidly in a favorable environment and, when not affected with disease, makes very heavy yields. Nearly every garden contains a few plants for home use and some truckers grow the vegetable on a comparatively large scale for shipment to various markets. However, it would be grown to a much larger extent if it were not for certain diseases which are always more or less present. In Louisiana, these diseases nearly always cut down the yield from fifty to seventy-five per cent, and some years ruin the whole crop. On account of these troubles, most truckers do not care to risk a very large acreage in this crop.

DISEASES OF EGGPLANTS.

The eggplant is subject to a number of different diseases. The most destructive and the most important of these is the one caused by the fungus, *Phomopsis vexans*. While this disease is known by a number of different common names, the most appropriate one is eggplant blight. A number of different names, such as leaf spot, fruit rot, collar rot and wilt are often used for different forms of the disease. Other diseases which are often troublesome to some extent are the bacterial wilt, caused by *Bacterium solanacearum*, and the Sclerotium wilt, caused by *Sclerotium rolfsii*. These two diseases are usually local and only occasionally produce a serious loss. Besides these, there are several minor diseases, such as the Rhizoctonia rot and the eggplant mosaic. These are of but little economic importance. In this bulletin, only the eggplant blight will be discussed in detail.

DISTRIBUTION AND PREVIOUS WORK ON BLIGHT.

The eggplant blight seems to be present in all parts of the United States, but is apparently more troublesome in the southern part of the country along the ocean and gulf, where the rainfall and humidity are high. The disease was first studied about thirty years ago by Halsted (1) in New Jersey. In fact, this was one of the first diseases studied by that pioneer phytopathologist. He described some of the different stages of the disease, but he did not recognize that these were all different stages of the one trouble and he consequently described them as being caused by two different fungi. In later years, Smith (9, 10), Wolf (11), Harter (4) and Sherbakoff (5, 6, 7, 8) have studied the blight and have materially increased our knowledge of the disease and of the fungus which produces it. Reference to the articles published by these investigators will be made from time to time in this bulletin. At the Louisiana Experiment Station, this disease has been under observation and investigation for a period of about ten years, and in this bulletin are given the results which have been obtained.

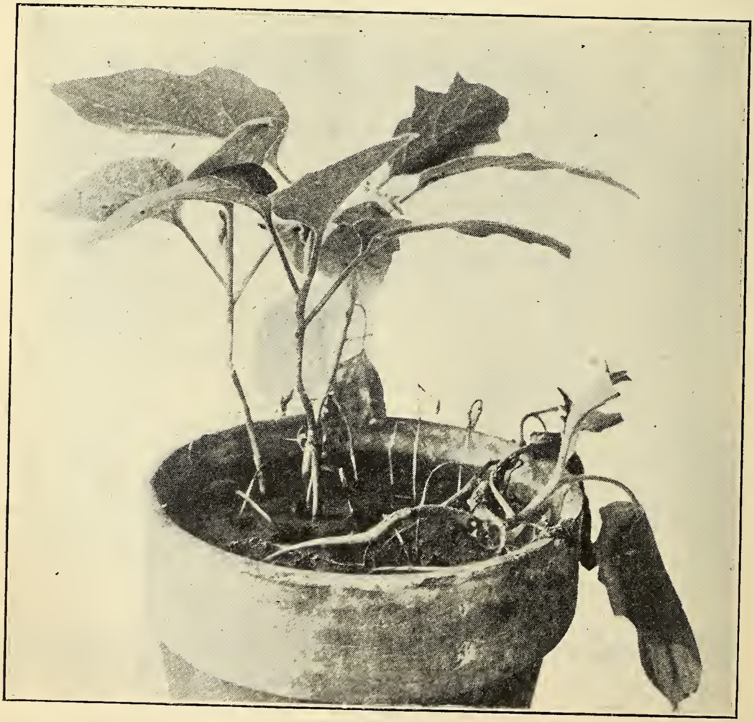

FIGURE 1.
Eggplant blight on young seedlings.

DESCRIPTION OF THE BLIGHT.

The blight attacks all parts of the eggplant above ground, including the stems, leaves and fruit, and occasionally it grows down into the roots from the stem lesions. It also attacks the plants in all stages of their development, often being present on the small seedlings as they emerge from the ground and remaining on the plants until they die with the disease or are killed by frost in the fall. The loss caused by the disease depends to a considerable extent upon the time of infection. If the disease is present upon the young seedlings, the crop produced is usually small. Normally, however, the disease does not become prominent until the plants are fairly large, and under these conditions, the plants generally make a fairly good early crop before the disease becomes widespread. After the plants become thoroughly infected, very little good fruit develops.

THE DISEASE ON THE SEEDLINGS.

Often, when infected seeds are planted, the disease shows on the young seedlings shortly after they are through the ground (Fig. 1). The young stem turns black at the surface of the ground and in a short time it rots off, causing the young plant to fall over and die. The appearance of these young plants is so similar to ones attacked by the common "damping off" fungus, Rhizoctonia, that it often takes a microscope to make certain which disease is present. Sometimes the blight can be told on the seedlings by the presence of the pycnidia which can be seen with a hand lens or even with the unaided eye, but the pycnidia are not always present.

THE DISEASE ON THE MAIN STEM.

In the fields set from seed beds in which the disease is present, plants often show an infection on the main stem. The stem (Fig 2) is usually affected near the surface of the ground. The extent of the infection is generally from two to six inches, though it may be as much as eighteen inches. This stem infection first manifests itself by the slow growth of the stem tissues. The infected portion of the stem is considerably less in diameter

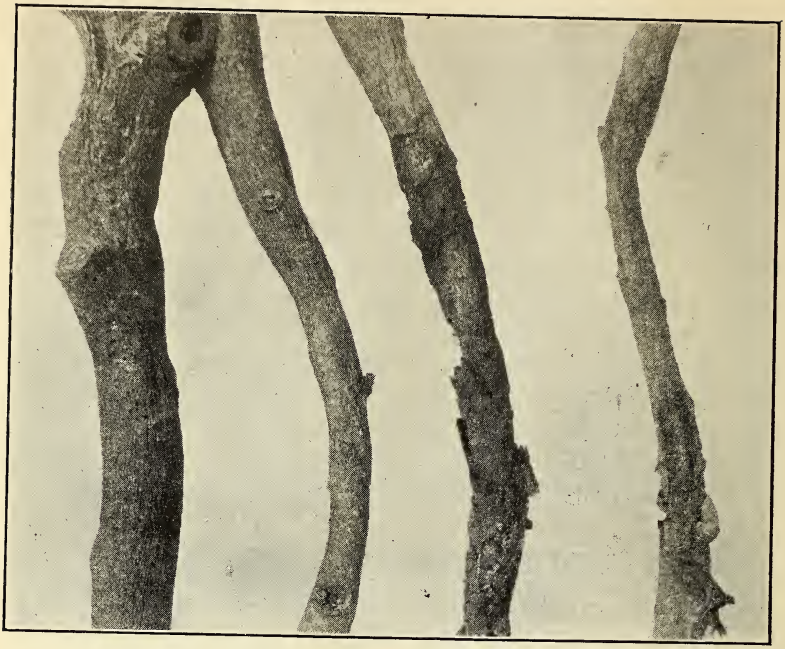

FIGURE 2.
Eggplant blight on large stems.

than the healthy portion either above or below. During the early stages, the outside of the stem looks perfectly healthy but later the layers of the cortex become black in color and dry up or rot off. Usually the bark cracks and peels off. Fruiting pustules may or may not form on these diseased areas. Harter (4), in his study of this disease, failed to find the fungus fruiting on the stems but the pustules have frequently been seen in Louisiana. Possibly a humid and warm climate is more favorable to their development.

The woody tissue in the inside of an infected stem usually becomes more or less dark in color, and this color frequently extends for a considerable distance beyond the portion that shows the disease on the outside. The inside of the stem frequently resembles very closely that of plants, such as cotton and tomato, that are affected with Fusarium wilt disease. In a recent article, Sherbakoff states that in the diseased stems of the eggplant, the woody tissue is not always discolored but observations made in Louisiana show that this color is nearly always present and is especially marked in the later stages of the disease. Direct

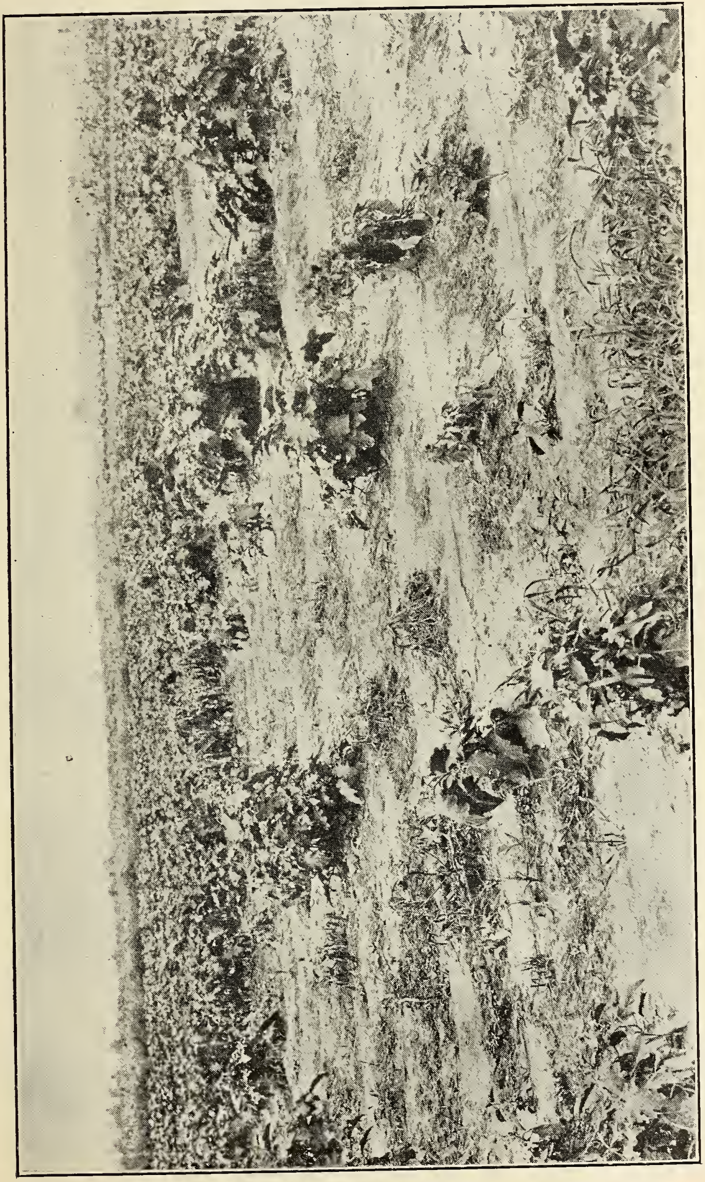

FIGURE 3.
Field of eggplants, showing the effect of the stem infection caused by the eggplant blight.

transfers made from this discolored woody tissue usually give pure cultures of the blight fungus.

As a rule, plants that have the stems affected do not grow very well and rarely produce any marketable fruit. The plants remain small and stunted and usually die early in the season. They rarely stay alive longer than the middle of the season. Sometimes the plants die very gradually, the leaves, beginning with the lower ones, slowly turning yellow and finally falling. Plants dying in this manner resemble cotton and tomato plants affected with the Fusarium wilts. At other times, however, the plants wilt very rapidly and die in a few days.

Sometimes in badly affected fields (Fig. 3) the number of plants showing stem infection will run as high as ninety per cent, but this is very unusual. As a matter of fact, the loss caused by stem infections alone is very small. Occasionally a badly diseased lot of seed will produce a high percentage of stem infections but under ordinary field conditions with the general run of seed, plants affected in this manner are scattering. However, from a control standpoint, these scattering diseased plants are very important, as they form centers of infection from which the whole field may become infected.

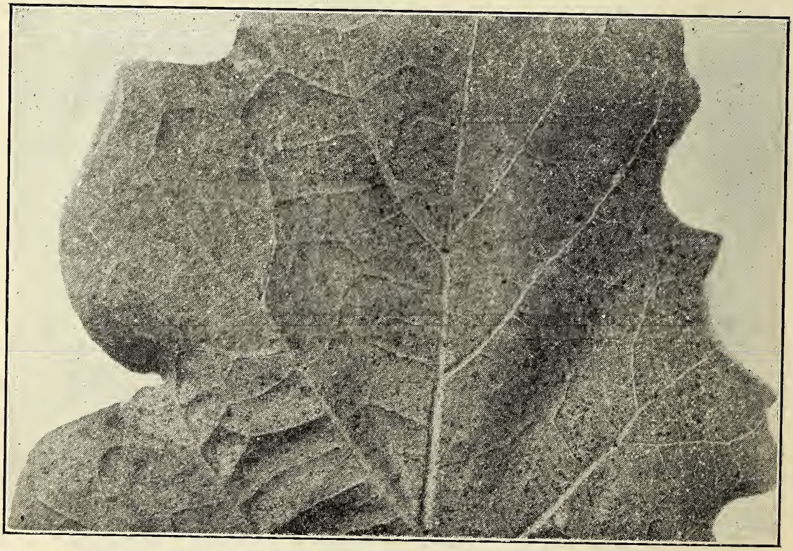

FIGURE 4.
First stage of eggplant blight spots on the leaves

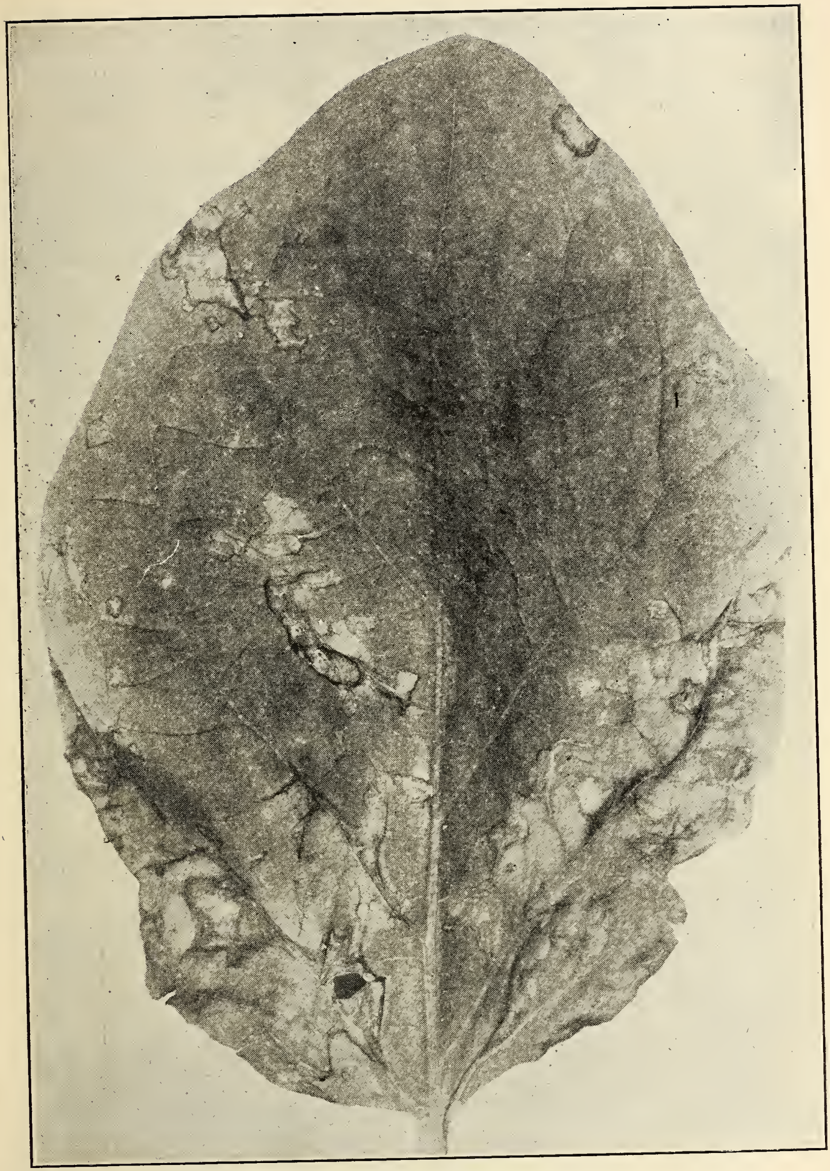

FIGURE 5.
Leaf spots produced by the eggplant blight.

This peculiar stem infection has been described by both Harter (4) and Sherbakoff (7). It is also very probable that

Halsted (2) noticed the same thing in New Jersey, as he speaks of a stem disease that occurred on the plants. He did not, however, associate the stem disease with the leaf and fruit infections.

THE DISEASE ON THE LEAVES.

Eggplant leaves are usually severely affected by the blight. As a rule, under field conditions, the presence of the disease is first recognized by the spots on the leaves. The spots generally appear first on the lower leaves, especially those that are in contact with the ground, and from these, the disease gradually spreads to the other leaves.

When the spots first appear, they are small, more or less circular in outline and brown in color (Fig. 4). Under favorable conditions these spots increase in size rapidly. As the development of the spots depends more or less upon the veining of the leaves, the older ones (Fig. 5) become variable in shape and size.

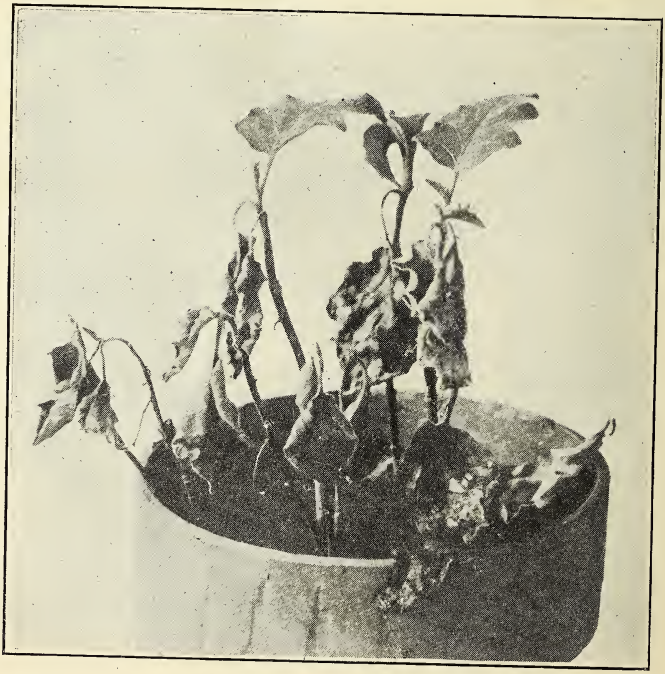

FIGURE 6.
Eggplant blight produced by inoculation, showing a serious leaf infection.

They always have a definite, clear cut margin. The spots coalesce readily and often cover nearly the whole leaf. After the tissue in the spot dries out it becomes somewhat lighter in color than at first. Sometimes when the disease is developing

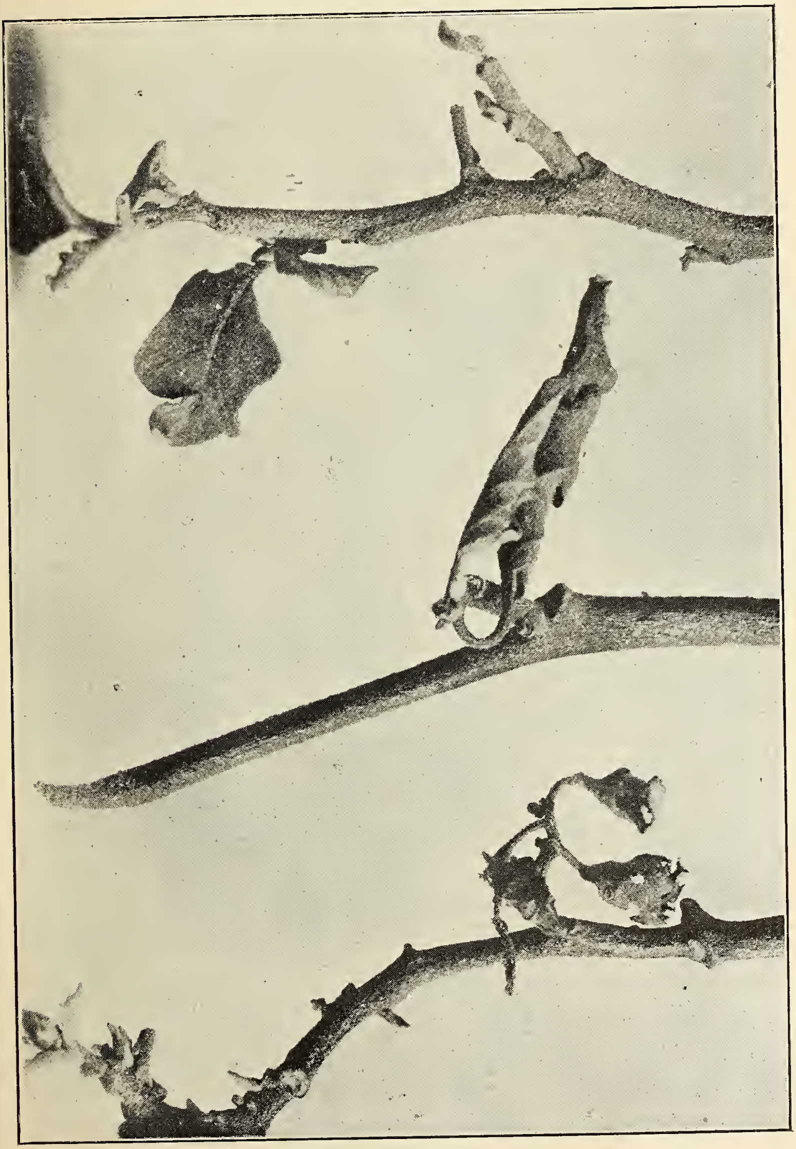

FIGURE 7.
Eggplant blight on the young leaves and shoots, causing their death before they fully develop.

very rapidly, the affected portion of the leaf will have a slight water-soaked appearance, but this soon disappears as the tissue dries. As a result of the disease, the affected leaves gradually turn yellow and finally die. They may hang on the bushes for awhile (Fig. 6) but they are much more likely to shed.

The blight also manifests itself in another way on the leaves, this being especially common during the last half of the season. The leaves and young shoots become affected while unfolding, with the result that they are killed before they have a chance to reach any size. In Figure 7, are shown several branches in which the young leaves have been killed in this manner. Late in the season, on account of this phase of the disease, it is often very difficult to find any leaves that have reached their full

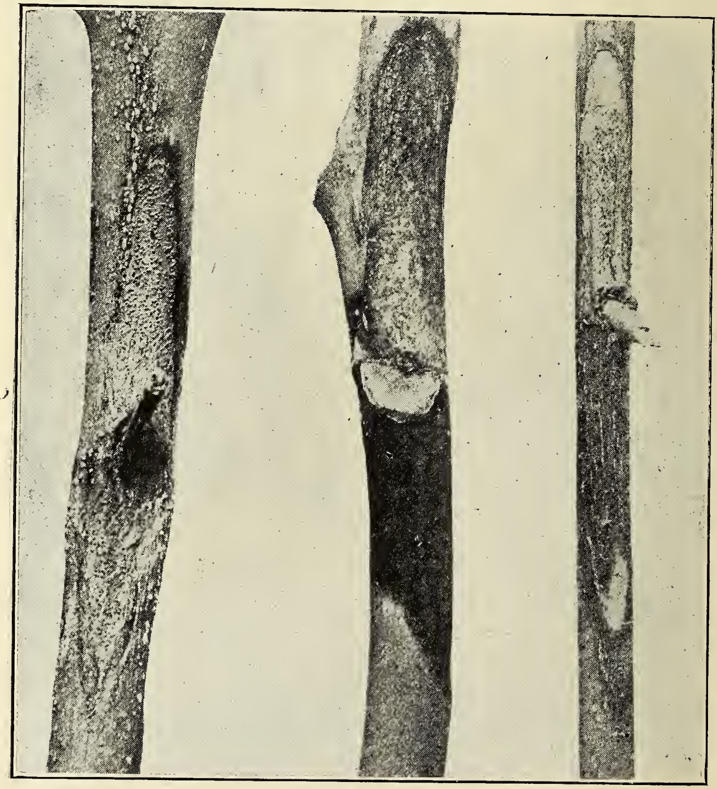

FIGURE 8.
Cankers on branches produced by the eggplant blight.

development. In Figure 16 is illustrated a plant that has been practically killed because of its inability to produce leaves. This form of the disease is really more serious than the leaf spot stage which is ordinarily noticed.

THE DISEASE ON THE BRANCHES.

On the branches, the disease develops in the form of long, somewhat sunken lesions (Fig. 8). These lesions may develop from any point of infection but they usually develop from a leaf or twig scar. The fungus grows back into the branch from the infected leaf. While this form of infection develops faster in the direction of the long axis of the branch, it also spreads to some extent around the branch. On young twigs, especially, it may form a complete girdle and cause the death of the whole apical portion of the branch. Late in the season, the number of branches killed in this manner is rather large.

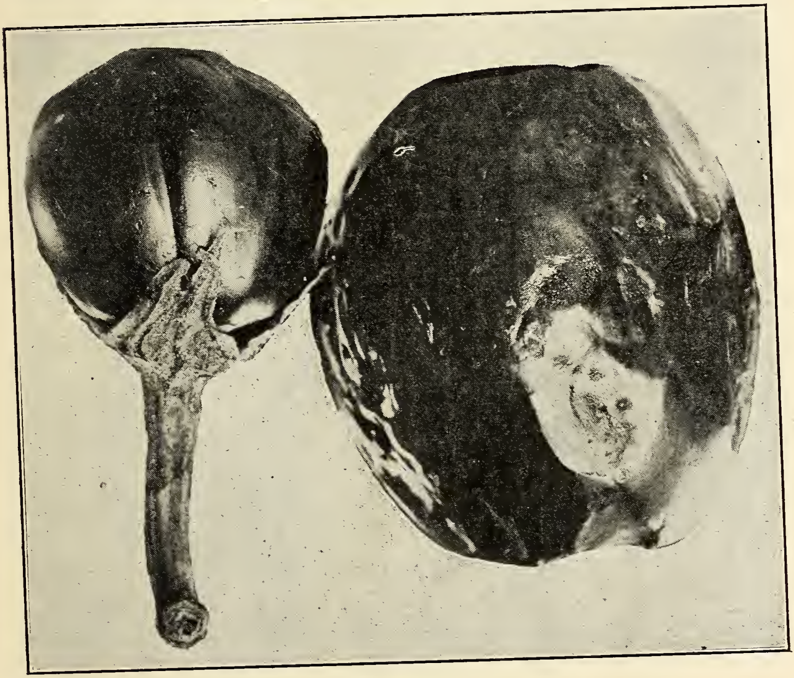

FIGURE 9.
Eggplant blight on the fruit and fruit stalks.

THE DISEASE ON THE FRUIT.

The eggplant fruit is very badly affected by the blight disease. In a favorable climate, the infection is usually so severe that only a small amount of fruit matures after the disease is well established. The disease appears in the form of spots or lesions (Fig. 9). These spots are sunken and more or less circular in outline, and vary considerably in size. When there are only one or two on a fruit they grow to a considerable size, often nearly covering the surface. When there are many, as is usually the case, they readily coalesce into one large lesion. These lesions may form at any place on the fruit but they are more common near the stem end. This is due to the fact that much of the fruit infection follows down the calyx lobes and fruit stalk. The fruit itself is covered with a waxy substance and does not wet easily and so the spores do not readily adhere to the surface. The calyx, however, becomes infected very readily (Fig. 10) and the fungus grows from this into the fruit stalk and then into the fruit itself.

The interior of the fruit (Fig. 11) decays rapidly. The tissue under the lesion becomes dark colored. At first it is somewhat spongy and dry but later it becomes more or less soft and watery. The seed-bearing areas of the fruit seem to rot faster than does the interior.

In the inside of the fruit, the fibro-vascular bundles are often discolored and show as black lines running from the lesions to the diseased stem. These lines show in Figure 11. The presence of these discolored bundles suggests that some of the lesions on the fruits may come from an inside infection.

Most of the fruits that are affected with the disease fall from the plants before reaching maturity. This is due to the fact that a considerable portion are affected at the stem end. After the fruit falls, the rot continues until all portions are affected. The fruit then dries down to a hard mummy, or if the weather is humid, disintegrates. The few fruits that do not fall, dry into hard mummies and remain hanging on the bushes for some time.

The blight fungus is found on all diseased areas on the fruit, calyx and fruit stalk. The fruiting pustules are seen as small dark-colored pimples, slightly larger than pin points. The fungus continues to fruit on the mummied fruits and also the dead fruit stalks throughout the season.

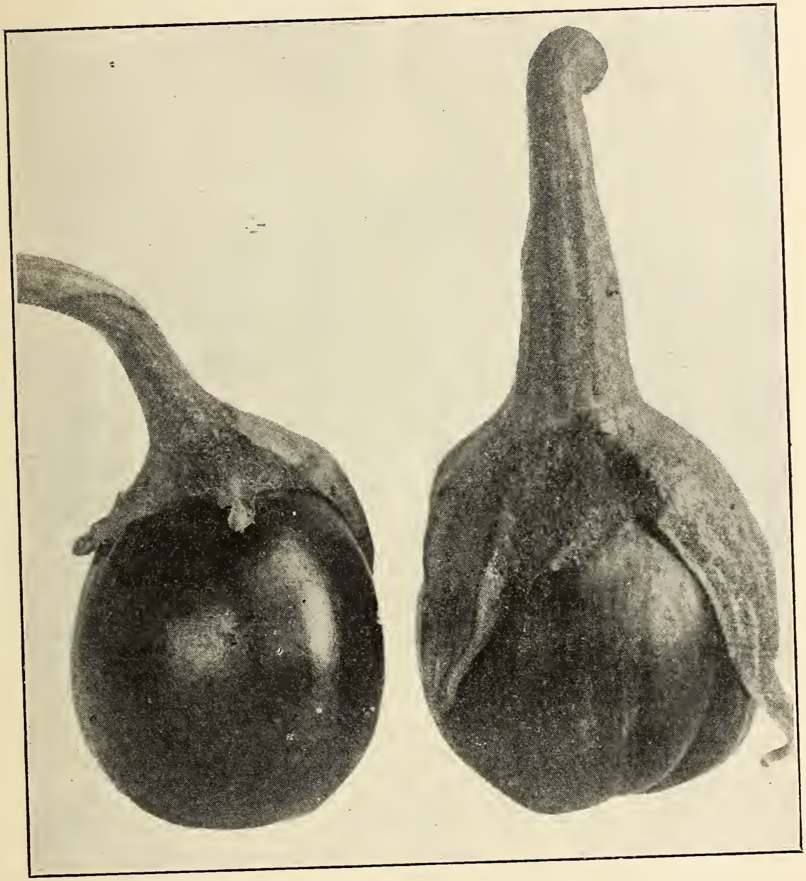

FIGURE 10.
Eggplant blight on the fruit stalk and calyx.

THE DISEASE ON AND IN THE SEED.

Studies made upon the eggplant blight show that it is capable of being carried over the winter on or in the seed. Young plants growing from seed planted in sterilized soil will frequently have the disease upon them. Whether this infection comes from spores on the surface of the seeds or from dormant mycelium within the seed coats has not been absolutely proven. It is more than likely, however, that the infection may come from either source.

Young plants growing from seed inoculated with spores before planting always show a heavy infection with blight. As tests have shown that the spores will retain their vitality for at least ninety-two days when dried upon cover slips, there remains little doubt that they will retain their vitality on the seed from harvest until planting time. This has also been demonstrated by a number of seed disinfection experiments. In practically every experiment in which disinfectants have been used upon eggplant seed, the percentage of infected seedlings has been reduced. The disinfectants could hardly do any more than to kill the spores or mycelium that might be on the surface of the seed.

That the fungus which causes the disease may also be present in the interior of the seed has been definitely proven. Sections have been made from seed from diseased fruit and the presence of mycelium within the seed coats has been demonstrated (Fig. 12). Extreme care was taken in selecting the fruit from which the seed were taken for sectioning. None were used that showed any sign of secondary infection. The mycelium is scattered around in the open places in the seed and to some extent within some of the cells. It has been observed in all parts of the seed, even touching the young hypocotyl. The mycelium, however, is not abundant in the seed and but very few cells show any disintegration. From the appearance of the sections, the seed were apparently good and able to germinate. The presence of the mycelium in apparently good seed makes it seem probable that the disease is carried over in this manner. This is difficult to prove as seed containing mycelium cannot be told from disease-free seed before planting, and there is always the possibility that the seed containing the mycelium will not germinate. However, it has been proven by experiment that it is impossible to entirely eliminate the disease from seed by treating them with disinfectants, such as corrosive sublimate and formaldehyde, and this would seem to show that the disease was present in some of the seed.

DESCRIPTION OF THE FUNGUS.

The fungus which produces the eggplant blight fruits abundantly on all affected parts of the plant above ground. The mycelium is in the diseased portions of the host and the fruiting bodies, or pycnidia, form on or just underneath the surface layers. The pycnidia are easily seen with the naked eye, showing as small black dots on the surface.

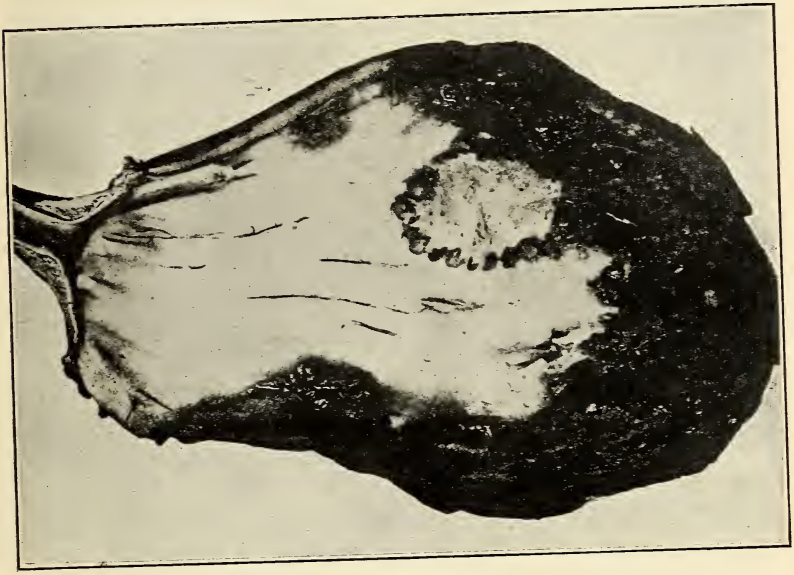

FIGURE 11.
Interior of fruit affected with eggplant blight, showing the decayed area, the black fibro-vascular bundles and the affected stem.

The pycnidia are extremely variable in shape and size, this being largely due to the part of the plant upon which they develop and also upon moisture conditions. In Figures 13 and 14 are shown some of the different forms that the pycnidia may assume.* They are usually decidedly flattened, though sometimes they are more or less sub-globose. They are generally em-

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*It should be borne in mind that there is another fungus found on eggplant which cannot be told from *Phomopsis vexans* except by culturing and testing by inoculation, and so it is impossible to say with absolute certainty that any particular pycnidium which may be sectioned is really *Phomopsis vexans*. The other fungus is described on a succeeding page in this bulletin. However, the pycnidia shown in Figures 13, a, b, c, and f and 14, a, b, c, and f were from the same material from which *Phomopsis vexans* was isolated and proven by inoculation.

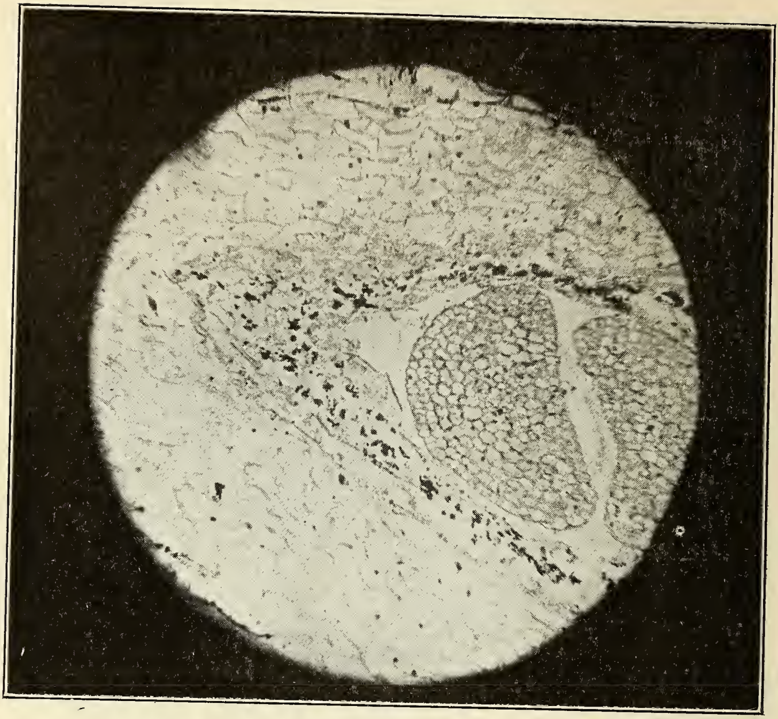

FIGURE 12.
Photomicrograph of a seed affected with the eggplant blight, showing the presence of the mycelium.

bedded or partly embedded in the host tissue, but if the development takes place under very moist conditions, they may be entirely on the surface. They may be more or less flattened on the top or the tip may be prolonged into a beak. The beaks are usually better developed on the pycnidia on the old stems but they are sometimes present even on the pycnidia that develop on the fresh fruits.

The pycnidial wall varies in thickness from 10 to 30 microns. It is usually thicker at the base of the pycnidium than on the sides. The pycnidia vary considerably in size. On leaves and fruit they are ordinarily about 125 to 300 microns in width and 110 to 250 microns in height; on stems on living plants, they are usually slightly larger; on old stems that have been dead for some time, they may reach a width of more than 700 microns and a height of 800 to 950 microns. In pure culture, where the

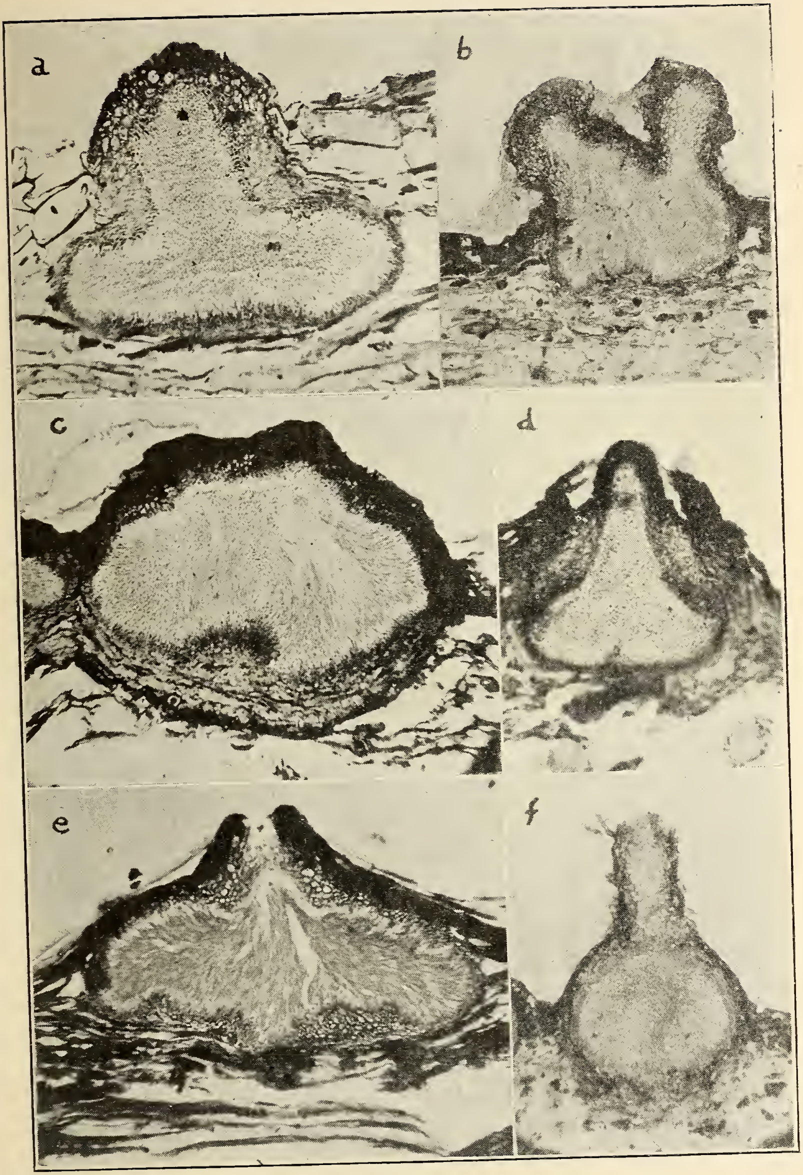

FIGURE 13.

Pycnidia of Phomopsis vexans. (a) From stem; (b) From fruit late in the season (c) From fruit stem; (d) From dead branches on living plant; (e) From dead stem; (f) From fruit late in the season.

pycnidia develop very irregularly, they often become still larger, often reaching a height of more than 1200 microns.

The pycnidia may also be more or less irregular. While a pycnidium ordinarily contains but a single cavity, there may occasionally be more in the larger ones. There may also be inclusions of various shapes projecting from the bottom of the pycnidium (Fig. 14a). Frequently also, the larger pycnidia may have more than one opening or beak at the top (Fig. 13b). The conidiophores upon which the spores develop form a layer over the entire inner wall of the pycnidium.

Two types of spores develop in the pycnidia. For lack of better terms, these will be spoken of as the Phyllosticta type of spores (Fig. 15a) and the Phlyctaena type (Fig. 15b). Spores of the Phyllosticta type are small, elliptical in shape, single celled, hyaline, about 6-8x3-4 microns in size and usually contain two prominent guttulae. These spores are typical of various species of the genera, Phyllosticta and Phoma, and it was in these genera that the blight fungus was placed for a number of years. Only in the past few years has any other spore stage been known for this fungus.

Spores of the Phlyctaena type are very long and narrow, about 18-32 x 1-1.8 microns in size, hyaline, continuous and usually sickle shaped, though they may be nearly straight at times. These spores are similar to those of many species described in the form genus, Phlyctaena.

The spores of the two types may develop in separate pycnidia or they may be produced in the same pycnidium. In Figure 14e is shown a pycnidium in which both kinds of spores are present. As a rule, the Phyllosticta spores are more abundant in the early part of the season upon plants on which the disease is developing rapidly, while the Phlyctaena spores are more abundant on old stems and mummied fruits. However, both spores are liable to be found at almost any time on any part of the plant. Both types of spores are remarkably constant in shape and size whether they form on leaves, fruit, old dead stems or in pure culture.

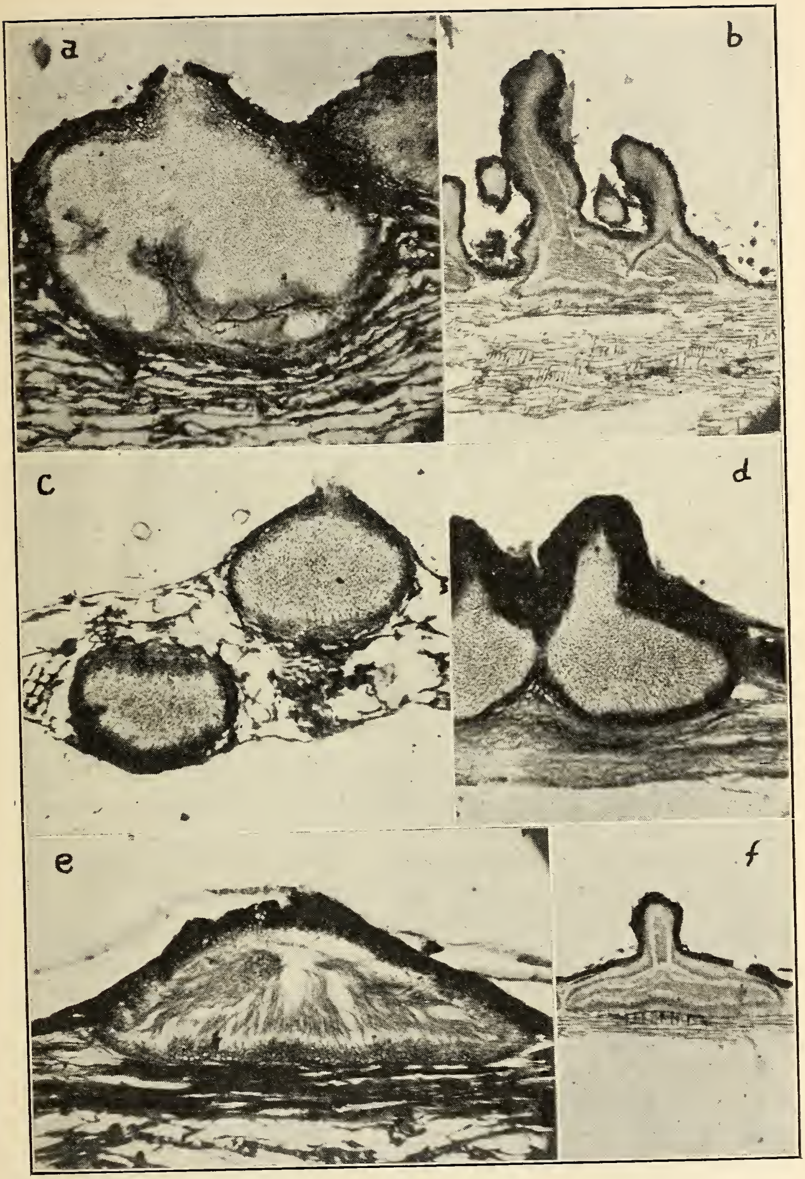

FIGURE 14.
Pycnidia of Phomopsis vexans. (a) From mummied fruits; (b) From old stems; (c) From leaf; (d) From dead branches on living plant; (e) From dead stem; (f) From old stem.

THE FUNGUS IN PURE CULTURE.

The fungus grows very readily on most of the ordinary culture media. Cultures are readily made by plating the elliptical spores or by transferring diseased host tissues from the fruits or stems to tubes. The growth is rapid in culture and pycnidia begin to develop in a few days. The fungus produces both kinds of spores in culture. With some strains, the Phyllosticta type of spores predominates, while with others, the Phlyctaena spores are more abundant. The optimum temperature for growth is around 29°C, though the fungus makes a good growth at any temperature between 21 and 32°C. The fungus grows equally as well either on a slightly acid or a slightly alkaline medium. It does not grow well on strong acid media. All attempts to germinate the Phlyctaena type of spores in culture media have been failures. This agrees with results obtained by other investigators.

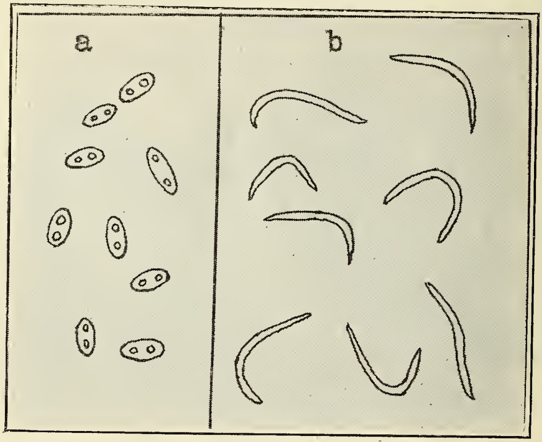

FIGURE 15.
Spores of Phomopsis vexans. (a) Phyllosticta type of spores; (b) Phlyctaena type of spores.

POSSIBLE ASCOGENOUS STAGE.

No ascogenous stage has as yet been proven to be connected with the blight fungus though an extended search has been made for one. Other similar species in the form genus, Phomopsis, have ascogenous stages in the genus, Diaporthe, and it is reasonable to suppose that the ascogenous stage of the blight fungus, if it is ever produced, would be in that genus.

An interesting member of the genus, Diaporthe, occurs very commonly on old diseased eggplant stems during the winter season in Louisiana, and it was thought for awhile that this might be connected with the blight fungus, but this has not been borne out by experiment. This fungus was first found during the winter of 1913-14 on old stems that had been left out in the open to winter. Since that time, it has been found during practically every winter. This fungus produces perithecia with long hair-like beaks which project for some distance above the surface of the stem.

This fungus has been repeatedly isolated in pure culture by transferring single asci to plates. The ascospores germinate readily and the fungus grows rapidly in pure culture. Cultures of the Diaporthe are practically identical with those of *Phomopsis vexans.* The Diaporthe cultures produce two kinds of spores that cannot be told from the spores produced by the blight fungus. In order to determine whether the Diaporthe fungus had any connection with the Phomopsis, a great many inoculation tests have been made during the past several years. In not a single test has the Diaporthe produced any infection on eggplants, while cultures of the Phomopsis used at the same time always produced the blight disease. This would seem to show that the Diaporthe has no connection with *Phomopsis vexans.* Non-pathogenic cultures have also been frequently obtained from eggplant stems on which no perithecia were present. While impossible to prove, it was assumed that these developed from conidia of the Diaporthe fungus.

IDENTITY AND NOMENCLATURE OF THE FUNGUS.

Until recently in the United States, the fungus causing the eggplant blight was known under the name of *Phyllosticta hortorum.* This was the name used by Halsted in his early investigations. The fungus has also gone under the names of *Phoma solani* and *Ascochyta hortorum.* In a recent publication, Harter considers that none of these names can be used and he uses instead, *Phomopsis vexans.* It is not necessary to discuss in detail the identity, nomenclature and synonomy of this fungus, as this is all included in Harter's article. With our present knowledge of the fungi occurring on eggplants, both in the United States and Europe, the name suggested by Harter, *Phomopsis vexans,* seems to be the one most acceptable for the eggplant blight fungus, and consequently, the one used in this bulletin.

VARIATIONS IN CULTURES.

During the course of this investigation, a hundred or more different cultures of *Phomopsis vexans* have been isolated and studied to some extent. These different cultures, or strains, have shown some interesting variations. Three distinct types of variation have been noticed: variation in manner of infection, variation in rate and manner of growth, and variation in the ratio of the two kinds of spores.

As regarding manner of infection, some strains have shown a greater ability than others to attack the main stem and a lesser ability to attack the leaves. This was particularly noticeable in two strains that were isolated at nearly the same time, one from a stem and one from a fruit. The first strain would produce a very heavy damping off in the seed bed but would only produce a moderate infection on the leaves. The second strain would produce a heavy leaf infection but would not cause the plants to damp off as severely as the first strain. This variation, however, was one of degree only.

The variation in the manner and rate of growth of different cultures has been very marked. Some cultures on the same medium would grow two or three times faster than others. Furthermore, the slow-growing strains would make an uneven growth. Certain portions of a colony would grow faster than other portions. This uneven growth was not noticeable in the fast-growing cultures. Some strains showed this slow and uneven growth immediately after isolation, while others seemed to change from the fast to the slow growth after growing for some time in culture. Not all cultures, however, showed this change in manner of growth. Some have been carried for years without showing any change in habit of growth. Both the slow and fast-growing cultures, when used in inoculation experiments, produced abundant infection. No satisfactory explanation can be given for the variation in manner of growth.

Cultures of *Phomopsis vexans* produce both the short elliptical spores and the long narrow ones, but different cultures show a great variation in the percentage of the different spores. In some cultures, the elliptical spores predominate, while in others, the long spores are more abundant.

COURSE OF THE DISEASE.

The normal course of the eggplant blight in the field is comparatively simple. The first infection in the spring may come from one of two sources, from the use of diseased seed for planting, or from spores from old diseased plant parts that have been left in the field from the preceding year.

If diseased seed is used for planting, the disease will be present on the young plants as they come out of the soil. A portion of the young plants will damp off but some of them will remain alive and will be set in the field with the disease on them. The disease is carried to the field either as stem or leaf infections. If old diseased plants of the previous year are left in the field or in the immediate vicinity, spores developing on them will be carried to the growing plants and will start the leaf spot stage of the disease. After the disease gets a start in the field, it spreads rapidly. It usually first shows on the lower leaves and then spreads to the upper leaves, fruit and stems. Spores develop abundantly and these are readily carried about by wind, rain and insects.

INOCULATION EXPERIMENTS.

While this study of the eggplant blight has been in progress, a large number of different inoculation experiments have been conducted. These tests were necessary, not only to determine the period of incubation, and method of infection, but also to determine whether the different fungi in culture were really *Phomopsis vexans*. As was stated on a previous page, cultures of another fungus, which could not be told from *Phomopsis vexans,* were frequently isolated from eggplants and it was necessary to test every culture by inoculation in order to prove its identity. A large percentage of these inoculation experiments were carried on in the greenhouse. Field tests were found to be impractical on account of the great danger from outside infection. Most of the greenhouse tests were made by either spraying young plants under bell jars, with a suspension of spores in water, or by inoculating eggplant seed before planting.

From the greenhouse tests, it was found that the normal period of incubation was from seven to nine days. In a few tests when the weather was warm and the conditions were very favorable, the spots first showed in slightly less than seven days, while in a number of tests carried on in cool weather, the period was considerably more than nine days; but in a large percentage of the tests conducted under ordinary temperature conditions, the spots usually showed between the seventh and ninth days.

The spots first showed as very small brown specks (Fig. 4). These grew rapidly and in three or four days they were two to four millimeters in diameter and had the ordinary appearance of blight spots.

It was not necessary to injure the host tissue in order to have infection. The fungus entered easily the uninjured epidermis. Often there would be hundreds of spots on a single leaf.

In the seed inoculation experiments, the seed were dipped in a very heavy suspension of spores and usually planted immediately afterwards. In all cases with virulent cultures, the young plants began to die shortly after they came through the ground. Some of the plants died very quickly, while some stayed alive until they were fairly good size (Fig. 1). Furthermore, some of the plants, although infected, had the external appearance of being healthy, even when they were large enough to be set in the field.

CROSS INOCULATION EXPERIMENTS.

All attempts to inoculate plants other than eggplant with *Phomopsis vexans* have been unsuccessful. Many tests were made with potato, tomato, pepper and some wild species of Solanum but no trace of any infection followed. These tests were made under the best of conditions and eggplants were always used as checks. In all of the tests, the eggplants took the disease readily.

SEED AND SOIL TREATMENT.

During 1913 and 1914 some experiments were run to test out the effect of seed and seed bed treatment on the health of the plants after they were set in the field. The treatments included the sterilization of the soil in the seed bed, disinfection of the seed with formaldehyde and the inoculation of the seed with spores of the blight fungus.

In 1913, two lots of soil were used in the seed beds, these being identical with the exception that one lot was sterilized by heat in the autoclave. In each soil was planted seed treated in five different ways, as follows: (1) Seed left untreated as check; (2) seed treated for fifteen minutes with a formaldehyde solution, made by mixing one part of commercial formaldehyde with 300 parts of water. (3, 4, 5) Three lots of seed treated with three different cultures of *Phomopsis vexans.*

Eggplant seed are not very resistant to disinfecting solutions and preliminary experiments showed that the formaldehyde treatment given above was as strong as could be used without materially injuring the germination of the seed. In fact, this treatment decreased the germination to a slight extent.

The plants were grown in the greenhouse and then at the proper time they were planted in duplicate plots in the field. At various times during the following summer counts were made of the number of plants that were dead or badly diseased. Plants with leaf spots alone were not counted as badly diseased, as spots were present on practically all of them. It was the aim to count only the plants on which the disease had been carried to the field from the seed bed. As a matter of fact, the plants counted were largely the ones with stem infections. In Table 1 are given the results for the two plots. In the table the three lots treated with three different cultures are combined.

TABLE I.

Effect of Seed and Seed Bed Treatment on Eggplant Blight.

Soil Treatment in Seed Bed.	Seed Treatment	Total Number of Plants.	Percentage of Good Plants	
			June 2-3	June 27
Sterilized.............	None..............	18	75.0%	55.0%
Sterilized.............	Formaldehyde.......	184	70.0%	56.0%
Sterilized.............	Inoculated with *Phomopsis vexans*.....	552	17.5%	6.0%
None...................	None..............	184	70.0%	46.0%
None...................	Formaldehyde.......	184	85.0%	78.0%
None...................	Inoculated with *Phomopsis vexans*.....	552	31.0%	10.5%

An examination of the table shows several points of interest which may be briefly mentioned:

1. Growing untreated seed in sterilized soil in the seed bed did not have any marked effect on the severity of the disease in the field after the plants were transplanted. However, the use of sterilized soil did increase the disease in plants that grew from seed inoculated with spores. These plants were more severely affected in the seed bed before transplanting than were those in the unsterilized soil, and as was to be expected, later showed more of the disease in the field. The increased severity of the disease in the sterilized soil was due to the fact that the sterilization eliminates the common bacteria and fungi in the soil and gives the parasite a better chance to develop.

2. The formaldehyde treatment decreased the disease to a slight extent in the unsterilized soil but did not seem to have any influence in the sterilized soil.

3. The inoculation of the seed with the blight organism caused a very heavy increase in the amount of disease present. While not shown in the table, the three different cultures were not equally virulent. One of the cultures was much more virulent than the other two and produced a much higher infection in every case.

EXPERIMENTS IN 1914.

In 1914, experiments were tried with two different lots of seed. One lot was ordinary commercial seed, while the other was seed that was saved from diseased fruits at Baton Rouge the preceding fall. The commercial seed was extremely poor, showing a very high percentage of infection wherever planted. The seed saved from diseased fruit was much better than the commercial seed.

The commercial seed was used for an inoculation test. Some of the seed were inoculated with a suspension of spores of *Phomopsis vexans* just before planting. As a check, some of the same seed were used without being inoculated. Both lots were planted in sterilized soil in the greenhouse.

The seed from diseased fruits was used for a disinfection experiment. Some of the seed were treated with a 1-300 formaldehyde solution for fifteen minutes just before planting, while another lot was left untreated. These seed were also planted in sterilized soil in the greenhouse.

On March 4, when the plants were from two to three weeks old, they were examined for the disease. The plants from inoculated seed were found to be badly infected. Many plants were already dead; some were dying, and part of the rest had leaf spots. On counting the plants in one row in the seed bed, thirty-three were found to be dead or diseased, while twenty-five were apparently healthy. The fungus was fruiting on many of the plants. Some plants that grew from the seed saved from diseased fruit also showed a little of the disease, but the infection was not heavy. There was also some infection on the plants that grew from the uninoculated commercial seed. In the spring these plants were set in the field and they were watched throughout the summer. On July 22, a count was made of the good plants. As in the preceding year, stem infections alone were considered in separating the good and poor plants, as leaf spots were present on all. In Table 2 are given the results.

TABLE 2.

Effect of Seed Treatment on Eggplant Blight.

Seed Used	Seed Treatment	Number of Plants	Percentage of Good Plants
Commercial	None	186	9.7%
Commercial	Inoculated with *Phomopsis vexans*	72	2.8%
From diseased fruits	None	256	86.0%
From diseased fruits	Formaldehyde	339	94.0%

As seen by the table, the commercial seed were very poor and consequently the value of this test was reduced. Yet even with the poor seed, the inoculation with the blight fungus increased the infection.

The formaldehyde treatment again reduced the infection to a slight extent but did not eliminate it. It seems probable that a considerable portion of the infection was on the inside of the seed and consequently could not be easily eliminated by seed disinfection.

VARIETAL RESISTANCE.

Eggplant varieties do not show equal resistance or susceptibility to the blight disease. Of the three common varieties, Black Beauty, Mammoth Purple, and Florida High Bush, the Florida High Bush is much more resistant to the disease. Plants of this variety will usually continue to make a few fruits all through the summer, even when the blight is very severe and long after the Black Beauty and Mammoth Purple plants are practically defoliated. The resistance of the Florida High Bush results in greater yields and a longer picking season. (See Tables 3 and 5, and Figure 18.) The Florida High Bush takes the disease easily and is injured severely, but compared to the other varieties, it shows considerable resistance.

For no other reason than its relative resistance to the blight disease can the popularity of the Florida High Bush in certain parts of the South be explained. It lacks both the quality and earliness possessed by the Black Beauty. Also when the blight is not present it does not yield as well. However, with the blight present, as is usually the case, it far exceeds varieties of the Black Beauty type in yield.

CONTROL OF THE EGGPLANT BLIGHT.

The eggplant blight has been found to be a disease very difficult to control in a climate such as that of Louisiana. None of the ordinary control methods have given satisfactory results. The reasons for this are rather numerous and include the following: (1) The ability of the fungus to live over the winter on and in the seed; (2) The ability of the fungus to live over the winter and develop the following spring and summer on the old dead eggplant parts; (3) The ability of the fungus to develop on any part of the plant above ground; (4) The great rapidity with which the fungus develops and spreads in the field; (5) The ability of the fungus to attack the interior portions of the stems; (6) The abundance of spores that the fungus is able to produce on affected portions of the eggplant; (7) The extreme susceptibility of most eggplant varieties; (8) The presence of stellate hairs on the leaves, which readily hold the spores and also prevent the satisfactory spreading of spraying solutions; and (9) the waxy covering on the fruit which hinders the sticking of spray solutions.

In controlling or checking a disease of this character, a number of things must be taken into consideration. These include the use of clean seed and rotation, the burning of all plants at the end of the season, seed treatment, the use of strong plants, and protection by spraying.

CLEAN SEED AND ROTATION.

As the eggplant blight is commonly carried over the winter on and in the seed, the use of clean seed becomes very important. It is impossible to buy seed known to be free of the eggplant blight on the market. Many different lots of seed have been used during the progress of this work on this disease and practically all have shown more or less disease present. Occasionally a lot of seed is very severely affected like the lot described on a previous page under ''Seed Treatment,'' where more than ninety per cent were affected, but this is very unusual. Usually there is just enough of the disease present to start a good infection in the field.

Possibly the best procedure at present would be for each grower to save his own seed, provided he can find fruits free of the disease. Seed saved from the first fruits to ripen would be the most satisfactory, as these are less likely to be affected.

Rotation is absolutely necessary. The blight fungus lives over very readily from one year to the next on fragments of old plants that may have been left in the field. Nothing less than a three years' rotation should be used, and furthermore, the new field should be as far away from the one of the preceding year as is possible to have it.

Planting home-saved seed on new ground, however, does not ordinarily prevent an outbreak of the disease, though the chances are that it will be delayed. A number of attempts have been made to grow a healthy crop on the Experiment Station grounds by planting seed saved from healthy fruit at some distance away from the eggplant plots of the previous year. None of these have been entirely successful. While the disease was slower in getting started in these fields, it was never eliminated. Whether this was due to a failure to obtain absolutely healthy seed or whether the disease started from some infectious material in the neighborhood was never definitely determined. The latter, however, seemed the most probable.

There is even the possibility that the fungus will live and spread as a saprophyte on old dead vegetation other than that of eggplants.

DESTRUCTION OF OLD PLANTS.

As the disease lives readily from year to year on the old dead plants, it is very evident that these should be pulled up and burned as soon as the crop is over. The sooner the plants are destroyed, the better is the chance of eradicating the disease. The plants should never be disposed of in any other way than by burning.

TREATMENT OF SEED.

The seed experiments which have been tried have never given entirely satisfactory results. As has been explained, on a preceding page, this is probably due to the fact that some of the infection is within the seed coats. However, the use of formaldehyde has, in nearly every case, been followed by a slight decrease in the amount of disease and consequently its use is to be recommended. The seed should be soaked for not longer than fifteen minutes in a solution made by mixing one part of commercial formaldehyde in three hundred parts of water. A longer treatment, or a stronger solution is likely to injure the germination of the seed. The seed can be planted immediately after the treatment.

USE OF STRONG PLANTS.

A very important thing to be considered in the control of the eggplant blight is the use of very strong plants. Young eggplants should receive very different treatment in the seed bed than plants of almost any other vegetable. It is the ordinary practice with tomatoes, cabbages, peppers and other similar plants to hold back the water in the seed bed in order to check their growth and produce a strong root development. This practice, however, is not suitable to the eggplant. The growth of a young eggplant should not be checked. A stunted eggplant will recover but its recovery is slow. The most desirable practice is to push the growth as much as possible. This is best accomplished by giving the young plants plenty of room in the seed bed and also plenty of water after the danger of damping off is past. When the plants are set in the field, they should be in a rapidly growing condition. If the plants are in this condition, they will start growth immediately and will grow rapidly, with the result that they are likely to make a good early crop before the blight has a chance to injure them materially. However, if the plants have to recover from an early checked or stunted growth, they will be so far behind that the blight is likely to ruin them before many fruits are produced. This is very well illustrated by an experiment conducted during the season of 1920. Seed of three different varieties were planted in two different seed beds. In one seed bed, the plants were given plenty of room and plenty of water; in the other seed bed, the plants were more crowded and the water was held back as is customary with many other plants. The plants in the latter bed did not suffer from lack of water but they did not make the vigorous growth the others did. The seed was planted during the first week in February and the plants were set in the field about the middle of April. Plants from the first bed ripened fruits for two weeks before those from the other bed. Plants from both beds reached their maximum production during the week ending July 10. After that date, the yield of all was greatly reduced by the blight. But up to that time, the plants from the first seed bed had been producing for five weeks, while the plants from the other had been producing for only three weeks. In Table 3 is given the total yield of fruits for the entire season, figured on a basis of a hundred plants. The yield by weight, of course, paralleled the yield by number.

TABLE 3.
Yield From Strong and Stunted Plants.

Variety	Number of Fruits per Hundred Plants	
	Strong Plants	Stunted Plants
Black Beauty	374	320
Mammoth Purple	293	234
Florida High Bush	537	462

The difference in yield as given in the table represented a difference of practically two tons to the acre in favor of the plants that were not stunted in the seed bed; and this increase all came from the increased yield in the early part of the season before the blight ruined the plants.

PROTECTION BY SPRAYING.

As spraying with some fungicide, such as Bordeaux Mixture, is usually advocated for the prevention of such a disease as the eggplant blight, spraying tests have been made during the past four years. As spraying is often not as satisfactory in Louisiana, where the summer rainfall is very heavy, as it is in other parts of the country, results which have been obtained here may not be applicable to other sections. However, the results show the difficulties in the control of the disease.

SPRAYING EXPERIMENTS IN 1917.

During the season of 1917 three different varieties of eggplants—Black Beauty, Mammoth Purple and Florida High Bush—were used in a spraying experiment. Two rows were set with each variety and one row of each was sprayed. The plants were sprayed with 4-4-50 Bordeaux Mixture, on May 3, May 12, May 22, June 12 and August 29. The first spraying was made about three weeks after the plants were set in the field. The early part of the season was very dry and the disease did not develop severely until August. No particular difference was noticed during the early part of the season as to fruit rot, though there seemed to be slightly less leaf spot on the sprayed rows. During the latter part of the season, the plants that had been sprayed were greener and had more foliage than the unsprayed plants, but during this period practically all of the fruit rotted. The yield for the season of the individual rows is given in Table 4.

TABLE 4.
Yield in Spraying Experiments, 1917

Variety	Yields in Pounds per Row	
	Sprayed	Unsprayed
Black Beauty	582	652
Mammoth Purple	556	531
Florida High Bush	518	637

As shown by the table, the test in 1917 showed no beneficial results from spraying.

SPRAYING EXPERIMENTS IN 1918.

In 1918, a spraying test was made on two varieties, Black Beauty and Florida High Bush. Two rows of each variety were sprayed and two were left as checks. The plants were sprayed four times, May 14, May 29, June 27, and July 18. The spray solution was 4-4-50 Bordeaux Mixture. A count was made of the number of good fruits gathered during the season. The last picking of the Black Beauty was made on August 31 and of the Florida High Bush on September 10. No healthy fruits developed after these dates. The number of fruits gathered during the season is given in Table 5.

TABLE 5.
Yield in Spraying Fxperiment, 1918.

Variety	Yield in Number of Fruits	
	Sprayed	Unsprayed
Black Beauty	392	358
Florida High Bush	635	659

An examination of the table shows that spraying four times did not give satisfactory results in 1918.

SPRAYING EXPERIMENTS IN 1919.

In 1919, only a small patch of eggplants was available for a spraying test. However, a portion of a row consisting of eleven plants was sprayed with 4-4-50 Bordeaux Mixture, to which was added one per cent of oil distillate. The oil distillate was used as a sticker. The plants were sprayed on June 16, June 28, July 7, July 14, July 24, July 30, August 6, and August 13. By using a sticker and spraying the plants frequently, it was thought that they might be protected well enough so that they would hold the fruits. The oil distillate worked very well as a sticker, but the disease was not prevented. On August 26, there were practically no healthy fruits on either the sprayed or the unsprayed plants.

SPRAYING EXPERIMENTS IN 1920.

Having had such poor results in the previous experiments, an attempt was made in 1920 to keep the plants covered with the fungicide from the time of the first application until the end of the season. The field used for the test was divided into six equal plots and each plot was set with three different varieties, one row to each variety. The varieties used were Black Beauty, Mammoth Purple and Florida High Bush. Until the fruit started to develop, the spray solution used was 4-4-50 Bordeaux Mixture. During the rest of the season, one per cent of oil distillate was added to the Bordeaux. In Table 6 is given the dates each plot was sprayed and solution used.

TABLE 6.
Dates of Spraying and Solutions Used.

Plot No.	Bordeaux 4-4-50					Bordeaux and Oil Distillate							
	5-25	6-1	6-8	6-15	6-22	6-29	7-6	7-13	7-20	7-27	8-2	8-10	8 -17
1	×	×	×	×	×	×	×	×	×	×	×	×	×
2			×	×	×	×	×	×	×	×	×	×	×
3				×	×	×	×	×	×	×	×	×	×
4					×	×	×	×	×	×	×	×	×
5						×	×	×	×	×	×		
6													

As is shown by the table, Plot No. 1 was sprayed thirteen times, at weekly intervals, beginning on May 25. Plot No. 6 was left as a check and was not sprayed. The other plots were sprayed at weekly intervals but the spraying was not commenced as early as on Plot No. 1.

The spraying was frequent enough so that the leaves were covered with the solution at all times, even after the hardest rains. The fruits also were fairly well covered, though the solution did not spread as well on the waxy covering as it should.

The eggplants were gathered at frequent intervals and a record was obtained of the number and weight picked each week. The record included both the good and diseased fruit separately. The last picking was on August 19. After that date, no healthy fruit matured on either the sprayed or the unsprayed rows.

The soil in the different plots was as uniform as is possible to obtain, but after watching the plants through the season, it seemed evident that the plants in Plot No. 3 did not grow quite as well as those in the others. Also the Florida High Bush row in Plot No. 1 did not have an equal chance with the others as it bordered on a plot of sugar cane.

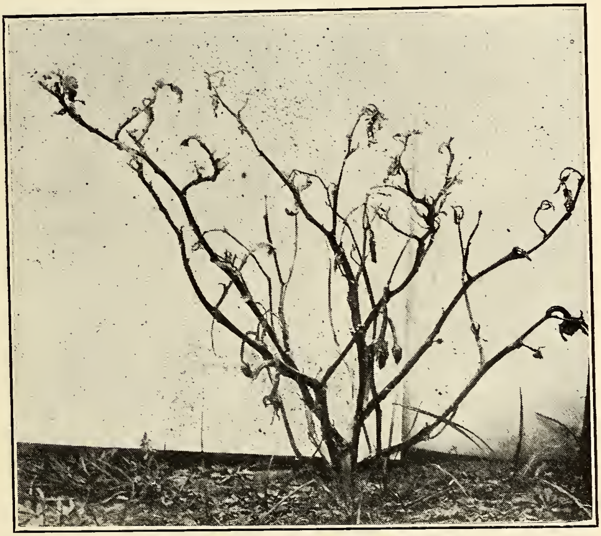

FIGURE 16.

Typical plant from unsprayed plot in spraying experiment in 1920. Plant photographed September 4, 1920.

The season of 1920 was very wet, making ideal conditions for the development of the blight. By July 1, spots began to show on the leaves of most of the unsprayed plants. This was at the time the first fruit were developing.

The spraying had a very evident effect on the appearance of the plants. The leaf form of the disease was prevented to a considerable extent. At the end of the season, the sprayed plants were fairly well covered with foliage, while the unsprayed plants were practically defoliated. The appearance of typical plants is shown in Figures 16 and 17. The spraying also checked the twig blight form of the disease. The spraying also checked the fruit rot to some extent, though this was not quite as marked as was the effect on the leaves. In Tables 7, 8, and 9 are given the results obtained with all of the varieties in all of the plots, including the total weight of healthy and diseased fruit and the percentage of fruits (by number) that were healthy at picking time. The weights are figured on an acre basis.

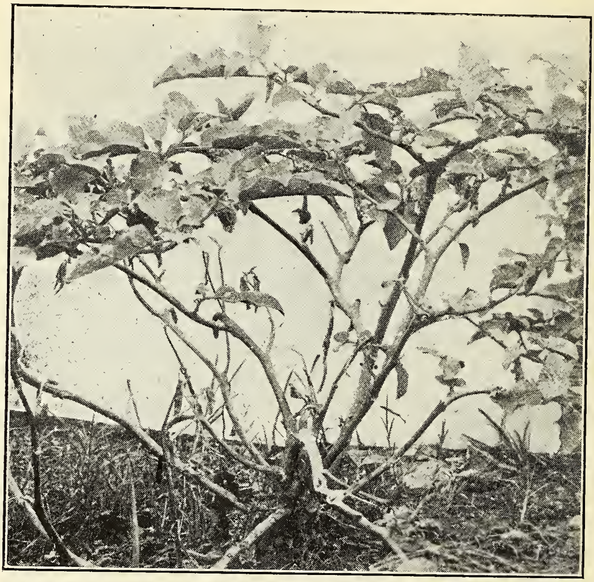

FIGURE 17.

Typical plant from plot sprayed eleven times. Variety, Black Beauty. Photographed September 4, 1920.

TABLE 7.

Results of Spraying Experiment, 1920.

Variety, Black Beauty.

Plot No.	Times Sprayed	Percentage of Fruit Healthy	Total Yield in Tons Per Acre	
			Good Fruit	Diseased Fruit
1	13	83	12.75	1.03
2	11	67	9.12	1.83
3	10	64	9.17	1.87
4	9	62	9.49	1.81
5	6	39	6.44	2.73
6	0	43	7.08	2 35

TABLE 8.

Results of Spraying Experiment, 1920.

Variety, Mammoth Purple.

Plot No.	Times Sprayed	Percentage of Fruit Healthy	Total Yields in Tons Per Acre	
			Good Fruit	Diseased Fruit
1	13	81	9.19	1.01
2	11	70	11.05	1.90
3	10	57	7.44	2.08
4	9	56	9.49	2.69
5	6	44	6.85	2.43
6	0	39	5.13	2.30

TABLE 9.

Results of Spraying Experiments in 1920.

Variety, Florida High Bush.

Plot No.	Times Sprayed	Percentage of Fruit Healthy	Total Yield in Tons Per Acre	
			Good Fruit	Diseased Fruit
1	13	83	9.94	0.77
2	11	81	14.04	1.07
3	10	61	8.73	1.97
4	9	73	10.50	1.23
5	6	71	10.64	1.42
6	0	48	7.86	2.57

An examination of the tables shows that there was a more or less gradual increase in the percentage of healthy fruits with the increase in the number of applications of the spray solution. In the plot sprayed thirteen times, more than eighty per cent of the fruit matured, while in the check, less than fifty per cent matured.

With the Black Beauty and Mammoth Purple varieties there was not much gained by spraying the plants only six times. It would seem that if the spraying is delayed until the fruits begin to develop, the disease cannot be readily checked on very susceptible varieties. With the Florida High Bush, a variety which is somewhat resistant to the disease, six sprayings materially checked the disease.

The actual results obtained in this spraying experiment are perhaps better shown by the curves in Figure 18. The curves show graphically the weight of good fruit picked each week from the check plot and also the one sprayed eleven times. The plot sprayed eleven times was used in preference to the one sprayed thirteen times, on account of the fact that one row of the latter was too close to a plot of sugar cane. The curves show that the picking season was considerably prolonged in the sprayed plots.

RESULTS OF SPRAYING EXPERIMENTS.

The spraying experiment conducted in 1920 shows that spraying will check the eggplant blight disease to some extent, provided that the plants are sprayed thoroughly and consistently every week from early in the spring until late in the season. However, it is very doubtful if such spraying will be found profitable. The cost of the spray material and the expense of application would in many cases, at least, be greater than would be the value of the eggplants that were saved. On account of the large size of the plants, it takes considerable solution and also considerable time and patience to spray thoroughly a block of eggplants. Unless a fairly high price can be expected for the crop, it is doubtful if spraying will be found profitable.

If the plants are not sprayed thoroughly and if the spraying is not continued through the whole season, the materials used and the labor expended are likely to be wasted. This was con-

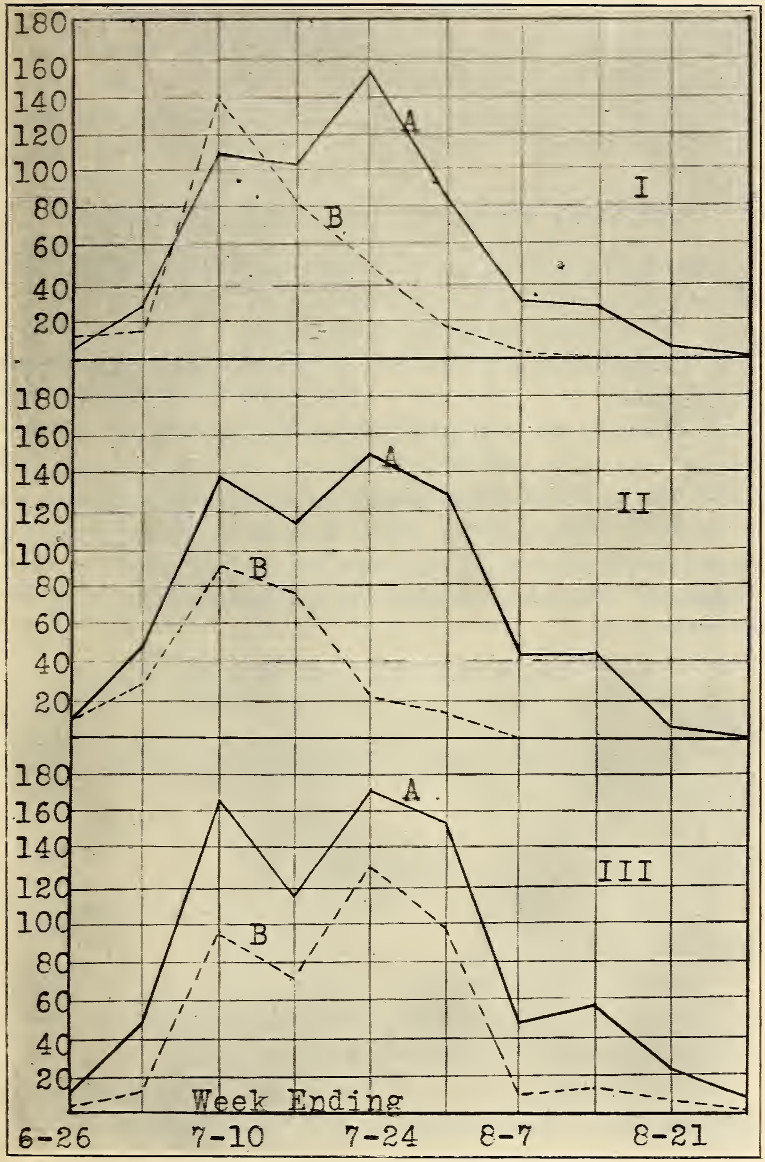

FIGURE 18.

Curves showing the number of eggplant fruits picked per week during the season of 1920 from one hundred plants in the unsprayed plot and from the same number in the plot sprayed eleven times. (A) Sprayed plants; (B) Unsprayed plants: (I) Variety, Black Beauty; (II) Variety, Mammoth Purple; (III), Variety, Florida High Bush.

clusively shown by the spraying experiments of the first three seasons and also by Plot No. 5, in the 1920 test. A few applications of the spray solution seem to have had no good effects. It is possible that in climates with less rainfall, spraying might become profitable.

GENERAL CONTROL RECOMMENDATIONS.

Briefly, the methods of control for the eggplant blight which can be recommended are as follows:

1. Use a three-year system of rotation.
2. Immediately after the crop is harvested, pull up and burn all the plants.
3. Disinfect the seed just before planting, with a 1-300 formaldehyde solution for fifteen minutes.
4. The young plants should be strong and vigorous when set in the field. This condition can be brought about by giving the plants plenty of room in the seed bed and by watering them frequently. The plants should not be checked by holding back the water.
5. The plants should be ready as early as possible.
6. In regions where the disease is severe, grow varieties that show some resistance to the disease.
7. If possible, use seed saved from healthy fruits during the first part of the season.

SUMMARY.

The points brought out in this bulletin may be briefly summed up as follows:

1. The disease of eggplants, known as the eggplant blight, and caused by the fungus, *Phomopsis vexans,* usually reduces the yield of eggplants in Louisiana at least one-half.
2. The disease occurs upon all parts of the eggplant above ground, producing leaf spots, fruit rot, stem cankers and twig blight. It also causes a damping off of the young seedlings.
3. The disease is carried over the winter on and in the seed. The mycelium of the fungus can be found on the inside of the seed.

4. The fungus produces two kinds of spores in extremely variable pycnidia.

5. No ascogenous stage has been proven to be connected with *Phomopsis vexans,* though a species of the genus, Diaporthe, which cannot be told from it in pure culture, is often found on dead stems.

6. The disease is easily produced by inoculation. The fungus is able to penetrate the uninjured tissues of the host.

7. The period of incubation is usually from seven to nine days.

8. Inoculation experiments on plants other than eggplants have not been successful.

9. The disease cannot be eliminated from the seed by disinfectants, but it can be reduced slightly.

10. Inoculating the seed with spores increases the amount of infection.

11. Spraying with fungicides, when properly done, will check the disease, but it is questionable if it will be found profitable.

12. All varieties do not show equal susceptibility to the disease.

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Louisiana Bulletin No. 179 March, 1921

Agricultural Experiment Stations

OF THE

Louisiana State University

AND

A. & M. College

BATON ROUGE

Feeding Ground Rough Rice, Etc.

TO

Horses, Mules, Hogs and Dairy Cattle.

A PRELIMINARY REPORT.

W. H. DALRYMPLE
Director

Feeding Ground Rough Rice, Etc. to Horses, Mules, Hogs and Dairy Cattle.

A PRELIMINARY REPORT

Since the reduction in the price of rice, a great many inquiries have been received by the Experiment Station from farmers, and others, in the rice-growing sections of the State with reference to the feasibility of utilizing rough rice, especially, but also Brewers' rice, as a feed for animals, with the view of enhancing the value of the product.

The majority of the inquiries have been as to the danger, if any, of feeding the rough rice; and the Station is issuing this preliminary report as early as possible in order to give rice farmers, and others who may be interested, the benefit of the results of some feeding tests just concluded, so far as the danger of rough rice is concerned.

It may be stated, however, that while the recent tests were made with hogs and dairy cattle, the Station conducted a test with mules a few years ago, the results of which were published as Bulletin No. 122.

Two Station mules, which might be classed as "cotton mules," were used, and the feeding continued for about six weeks. The initial total day's ration was composed of the following:—

	Lbs.
Ground rough rice	2
Cracked corn	6
Cotton seed meal	1½
Blackstrap molasses	4
Lespedeza hay	12

In order to exercise caution in feeding the rice, we began with the small amount mentioned above; but each succeeding week the amount of rice was increased and the corn decreased, until, during the last week the animals were receiving 8 pounds of rice, which was a complete substitution of the rice for the corn; or about 60% of the concentrated part of the ration was composed of ground rough rice. The day's rations were always divided into three portions.

The principal conclusions arrived at from this test were:

"That rough rice, when ground, and forming one of the ingredients of a mixed ration, may be fed with safety and benefit to horses or mules.

"That the day's ration may be composed of at least 8 pounds of ground rough rice for horses or mules doing moderately heavy work, and approximating 1,000 pounds live weight.

"That the other ingredients in the test rations proved suitable to mix with the ground rough rice, although other available feeding materials, if of the required composition to balance the ration, might be just as satisfactory.

"That when the prices of cereal (feeding) grains are high, etc., and other conditions warrant, ground rough rice may be found of considerable economic value as a feed for horses or mules, *if intelligently and systematically used.*"

The general health and condition of the two mules remained excellent throughout the test, with no indications, whatever, of any injurious physical effect from the rough rice.

While rough rice is probably fed in the unground state, better results may be had by grinding it, as the grain is hard, and much of it is liable to pass through the animal undigested, which, necessarily, is a waste. Consequently, we always recommend grinding, for best results.

Further, rice, alone, does not furnish all of the elements required, by the working animal especially, to maintain its muscular development, and, therefore, ought to be mixed with some other ingredient, or ingredients, of a more nitrogenous nature, to balance the ration. Besides the grain combination already given, one or two more mixtures may be helpful in suggesting how ground rough rice, and Brewers' rice may be used to advantage in the feeding of horses or mules:

1. 76% ground rough rice; 10% cotton seed meal; 14% alfalfa meal.
2. 60% ground rough rice; 30% brewers' rice; 10% cotton seed meal.
3. 40% brewers' rice; 10% cotton seed meal; 25% black-

strap molasses; 25% alfalfa meal, or short-cut peavine hay.

4. 33⅓% each of oats, cracked corn, and brewers' rice.

5. 33⅓% each of brewers' rice, rice bran, and oats.

Whenever available, it would be well to feed, as roughage, with any of the above mixtures, some of the leguminous hays, such as peavine, alfalfa, clover, or lespedeza. Other roughages may be used, however, but the grass hays or the straws, being deficient in the protein element, will not balance the complete ration as well as will hays from the legumes mentioned.

The illustrations marked 1, 2, 3, 4 and 5 are not rations, but mixtures, the amount of which may be fed according to requirements.

WARNING.

We have already heard of some bad results this season from feeding rice to working mules. However, the very best grain feed in the world is liable to produce digestive troubles in working horses or mules if not fed intelligently and with system; and rice is no exception. The main cause of trouble has been, and is, that the work stock have been given too much of their grain feed at a time, and are not fed often enough. It is much safer to divide the day's ration into three feeds, than to feed only twice a day, as the former comes nearer to the natural way the horse or mule, with its relatively small stomach, feeds; and it can make much better use of its feed, and with much less risk of indigestion, colic, etc., following.

A useful guide in feeding horses and mules is to allow, depending upon whether the work is light, medium, or heavy, from 1 pound to 1½ pounds of the concentrated or grain part of the ration, for each 100 pounds live weight of the animal, per day.

Up to 1,000 pounds, or so, live weight, this method answers very well; but as a small animal eats more, relatively, than a large one, some judgment is necessary when using this method in the feeding of heavy horses or mules, or one is liable to give them too much for their own good, besides wasting feed.

W. H. Dalrymple.

HOG FEEDING TESTS WITH GROUND ROUGH RICE AND BREWERS' RICE RESPECTIVELY.

Conducted by E. L. Jordan, A. F. Kidder,
Assisted by L. E. Long.

SUMMARY.

The primary object of these tests was to find out if ground rough rice and brewers' rice, respectively, might have any deleterious effect upon hogs consuming them, so as to be able to reply to inquiries bearing upon the subject.

Eighteen shoats, averaging six months of age, about 140 pounds in weight, were used, and the feeding period lasted forty-two days.

The hogs were divided in two lots of nine each, and these further divided into three lots with three hogs in each subdivision, or pen.

LOT ONE, WHERE GROUND ROUGH RICE WAS FED.

Pen I. Three hogs received tankage and corn meal as a standard ration.

Pen II. Three hogs received tankage and ground rough rice, the rice entirely replacing the corn meal.

Pen III. Three hogs received tankage and equal weights of ground rough rice and corn meal.

Each mixture was fed from a self-feeder.

The hogs in Pen 1, in both Lot 1 and Lot 2, or six hogs, each receiving tankage and corn meal, made an average daily gain of 2.04 pounds.

Those in Pen 2, receiving tankage and ground rough rice, made 1.86 pounds.

Those in Pen 3, getting tankage with ground rough rice and corn meal, made 2.19 pounds.

All of the nine hogs remained in excellent health and condition throughout the 42-day test.

The three animals receiving tankage and ground rough rice were not finished quite so well as the others, but as they were found infested with worms, this may have interfered, somewhat, with the more perfect digestion of the rough rice.

These three hogs consumed 943.5 pounds of ground rough rice in the 42 days, which was about 86% of ground rough rice in the ration, without any sign, whatever, of injury to the digestive organs, as proved by post-morten examination.

LOT TWO, WHERE BREWERS' RICE WAS FED.

Pen I. Three hogs received tankage and corn meal as a standard ration similar to those in Pen 1, Lot 1.

Pen II. Three hogs received tankage and brewers' rice, the latter replacing, entirely, the corn meal.

Pen III. Three hogs received tankage and equal weights of brewers' rice and corn meal.

Self-feeders were used as in Lot 1.

The hogs in Pen 1, getting tankage and corn meal, were averaged with those in Pen 1, Lot 1, in the daily gain in weight of 2.04 pounds.

Those in Pen 2, receiving tankage and brewers' rice, made 2.05 pounds.

Those in Pen III, receiving tankage, brewers' rice and corn meal, made 2.30 pounds.

The hogs receiving tankage and brewers' rice consumed 1,036 pounds of the latter in the forty-two days.

The nine hogs in Lot 2, like those in Lot 1, remained healthy and vigorous throughout the test.

Eight of the test hogs were slaughtered, and there was very little, if any, difference in the flavor of the meat; their average dressed weight was 75%.

The daily gains in weight, in all cases, were considered exceptional.

FEEDING GROUND ROUGH RICE TO DAIRY COWS

Test Conducted by R. C. Calloway.

SUMMARY.

Twelve cows were selected, at the Experiment Station Dairy Farm, based upon their average milk yield, and divided into two groups for the purpose of this test.

Before keeping their records, the cows had a preliminary period of twenty-one days in order to get them accustomed to the feed.

One group of six cows was given a standard ration from a mixture of 350 pounds of unbolted corn meal, 100 pounds of 7% cotton seed meal, and 100 pounds of wheat bran.

The second group of six cows, or the one receiving the ground rice, was fed from a mixture of 350 pounds of ground rough rice, and 100 pounds of 7% cotton seed meal.

The roughages fed to both groups of cows were similar, and included good corn and soybean silage, and good bright clean hay.

The test period ran for sixty days.

The average daily ration consumed by the six cows receiving corn meal, cotton seed meal and wheat bran was 10.4 pounds.

That consumed by the six cows fed ground rough rice and cotton seed meal was 9.7 pounds.

The average daily milk yield per cow, during the 60-day period, in the group receiving corn meal, cotton seed meal, and wheat bran, was 24.5 pounds.

That of the group getting ground rough rice and cotton seed meal, was 22.5 pounds.

It will be noticed that the cows consumed slightly less of the rice and cotton seed meal mixture than of the corn meal, cotton seed meal and wheat bran, and yielded 2 pounds less milk per day. This may be accounted for, in some measure at least, by the fact that the rice and cotton seed meal, alone, lacked the palatability of the other mixture; and it is reasonable to presume that, if the animals had eaten as much of the one mixture as of the other, their milk yield might have been about the same. It is probable, also, that the addition of a small quantity of molasses, say, might have made the difference by increasing the palatability of the rice and cotton seed meal mixture. The results show, however, that the mixture containing the rice compared quite favorably with the other mixture, which contained what might be termed ''all standard dairy feeds.''

The chief object of this test, like that of the others referred to in this report, was to find out if any injurious effects would result from the feeding of ground rough rice to cattle, especially when used as an ingredient of the cow's ration. In this case, 80% of the mixture was composed of the rice, which was fed for 60 days, plus the preliminary period, and with no ill effects, whatever, that could be observed on the digestive organs of the animals.

NOTE.—Besides the results summarized in this brief report, a considerable amount of data, of a more or less technical character, was obtained from these tests, which the Station hopes to be able to publish at a later date.

JULY, 1921 LOUISIANA BULLETIN NO. 180

LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE

AGRICULTURAL EXPERIMENT STATIONS
W. H. DALRYMPLE, DEAN AND DIRECTOR

BATON ROUGE, LOUISIANA

FEEDING BLACKSTRAP MOLASSES TO YOUNG CALVES

By R. C. CALLOWAY
IN CHARGE OF DAIRY FARM

FEEDING BLACKSTRAP MOLASSES TO YOUNG CALVES.

By R. C. CALLOWAY.
IN CHARGE OF DAIRY FARM.

The primary object of this experiment was to determine the physical effect of low-grade sugar-cane molasses when fed to young calves. Owing to a somewhat prevalent impression that blackstrap, when fed to young calves, was liable to produce scours, this experiment was undertaken at the Station Dairy Farm to test the truth or falsity of this impression.

The experiment was begun September 1, 1920, and continued through the first week in February, 1921. The calves used were all born on the Dairy Farm. Accurate records were kept from birth until the close of the experiment.

Fourteen calves were used, all of which were weighed at birth, and, afterwards, weekly. They were fed whole milk at first, and were gradually changed to skimmed milk, but at no definite time, usually, however, about the eighth week—some a little earlier; some later.

As soon as the calves would eat a little grain and some roughage, they were allowed a ration which consisted of a mixture of 100 pounds of wheat bran; 50 pounds of corn meal; 50 pounds of velvet bean meal; and 50 pounds of oats. The roughage consisted of corn and soybeans silage, and good, clean, bright hay of several varieties. The grain and silage were weighed, and the amounts fed varied with each calf, but were increased as the calves grew older and were able to consume larger amounts. They were permitted to eat all of the hay they desired.

The calves were divided in two lots of seven each, one lot, used as checks, were continued to be fed as described; while the other lot were fed molasses in addition. The molasses was weighed and fed on the grain immediately after the calves had been given milk. At the beginning no calf was fed molasses until it began to show signs of wanting to eat a little grain, and then only on a very limited scale—one to two ounces at each feed. The molasses was increased on an average of about two ounces each week, and at the close of the test, the older calves were consuming approximately two pounds per day.

The results obtained, together with the weekly averages of the amounts of grain, milk, molasses and silage consumed, are given in tabular form, besides a short history of each calf.

The irregularity in the number of weeks shown in some of the tables is due to the fact that the younger calves were brought into the test as soon as dropped, which, in some cases, was after the test had been commenced with the older ones.

While the original idea was to test the physical effect of the molasses only, it was decided afterward to add some figures to show the cost of raising calves to about six months of age, with and without the molasses; and also to show their average weekly gains at the current values of the feeds used.

This information will be found in tabular form at the end of the bulletin.

CONCLUSIONS.

Low grade sugar-cane molasses (blackstrap) may be fed to young calves with perfect safety. When the calves begin to consume a little grain, they can be given as much as one to two ounces with each feed. The molasses should be increased gradually. If this is done, the calves will soon get accustomed to it and will consume large quantities without physical injury. If permitted to eat all the molasses the calf may care to at any one time, it will more than likely cause scours, which if continued, will produce serious, if not fatal consequences.

Sugar-cane blackstrap is not laxative when fed with grain. Besides being nutritious in itself, it is a good appetizer, has a tonic effect, tends to make the grain more palatable, thereby causing the calves to consume larger quantities of grain, and drink larger quantities of water.

Blackstrap is an excellent conditioner; it will put the calves in fine condition; regulate the bowels; and keeps the skin and hair in good order.

COST OF RAISING THE CALVES.

According to the following figures, and with the feeds used, the average cost of raising a calf to six months of age, without molasses, was $60.00, and with molasses was $54.00.

It should be stated, however, that while these costs represent high-priced feeds, they are not a true criterion of what a six-months-old calf may be raised for, if fed less expensive concentrated materials. The object of the experiment was to test the physical effect of the blackstrap molasses, only, and not the economical feeding of the calves.

The wide variations found in the amounts of the feeds given to the calves from week to week, and also the variation in the average gains, is accounted for by the great susceptibility of young calves to changes in the weather, feed, and other conditions over which we have no control. All of which are evidences that the young calf must be watched very carefully, and fed according to its daily condition and requirements.

In order to raise calves successfully, the feeder must have a general knowledge of the subject, and then apply his knowledge in a practical manner. It is highly important, also, that sanitation be considered one of the most important factors involved in the raising of calves; that all milk must not be lower in temperature than the body-heat of the animal; and that all feeds be increased very gradually in amounts.

CALF No. 16 (Jersey)

Date of Birth, August 26, 1920. **Weight at Birth 50 lbs**

Average daily quantity of molasses, milk, silage, grain, and gain in weight.

Week	lbs. Molasses	lbs. MILK		lbs. Grain	lbs. Silage	lbs. Gain in Weight
		Whole	Skim			
1		10.0				.83
2		10.0				.85
3		10.0				.57
4		10.0				.80
5	2 oz.	9.6		4 oz.		.36
6	2 oz.	9.8		4 oz.		1.59
7	2 oz.	10.0		6 oz.		1.30
8	4 oz.	7.0	3.0	8 oz.	4 oz.	1.57
9	6 oz.	4.7	5.3	8 oz.	6 oz.	.64
10	8 oz.		10.0	8 oz.	8 oz.	.85
11	10 oz.		10.0	12 oz.	12 oz.	1.50
12	12 oz.		10.0	12 oz.	12 oz.	.85
13	14 oz.		10.0	1 lb.	1 lb.	1.21
14	1 lb.		10.0	1 lb.	1 lb.	.93
15	1 lb. 2 oz.		12.0	1 lb. 2 oz.	1 lb. 8 oz.	.93
16	1 lb. 4 oz.		12.0	1 lb. 4 oz.	2 lbs.	.57
17	1 lb. 6 oz.		12.0	1 lb. 6 oz.	2 lbs.	1.64
18	1 lb. 8 oz.		12.0	1 lb. 8 oz.	2 lbs. 8 oz.	1.00
19	1 lb. 10 oz.		12.0	1 lb. 10 oz.	2 lbs. 8 oz.	.70
20	1 lb. 12 oz.		12.0	1 lb. 12 oz.	2 lbs. 8 oz.	1.64
21	1 lb. 14 oz.		12.0	1 lb. 14 oz.	3 lbs.	.50
22	2 lbs.		12.0	2 lbs.	3 lbs.	.57
23	2 lbs.		12.0	2 lbs.	3 lbs.	1.30
24	1 lb. 12 oz.		12.0	2 lbs.	3 lbs.	1.14
Total for 24 weeks	147 lbs.	577.7	1248.1	156 lbs.	136.8 lbs.	
Cost....	$1.91	$23.10	$12.48	$3.12	$ .68	
Total Cost for 24 Weeks........						$41.29
Average Cost per Week........						$ 1.92

Calf No. 16, Jersey heifer, dropped August 26, 1920, weighed 50 pounds at birth. This was an average sized calf, strong and vigorous.

This calf received an average of about 16 ounces of molasses a day for nineteen weeks, beginning on the fifth week with 2 ounces a day and gradually increasing it until the end of the twenty-third week when she was receiving 2 pounds a day. She was never off feed. Her bowels were loose on September 29 and again on the seventh of October. At both periods, she was given 3 table-spoonfuls of castor oil in about 1 pint of milk. Her milk was reduced both times.

She was in good physical condition at the close of the test; her daily average gain was .98 pound.

CALF No. 17 (Holstein)

Date of Birth, August 30, 1920. **Weight at Birth 79 lbs.**

Average daily quantity of molasses, milk, grain, silage, and gain in weight.

Week	lbs. Molasses	lbs. MILK Whole	lbs. MILK Skim	lbs. Grain	lbs. Silage	lbs. Gain in Weight
1		11.0				1.25
2		12.0				.59
3		12.0				2.70
4	2 oz.	12.0		4 oz.		1.85*loss*
5	2 oz.	11.7		4 oz.		1.57
6	2 oz.	13.0		4 oz.		1.70
7	2 oz.	13.0		6 oz.		1.35
8	4 oz.	8.5	4.5	6 oz.	4 oz.	.78
9	6 oz.	4.8	8.2	8 oz.	6 oz.	2.00
10	8 oz.		13.0	8 oz.	8 oz.	1.85
11	10 oz.		13.0	12 oz.	12 oz.	2.28
12	12 oz.		13.0	12 oz.	12 oz.	1.70
13	14 oz.		13.0	1 lb.	1 lb.	1.14
14	1 lb.		13.0	1 lb.	1 lb.	1.64
15	1 lb. 2 oz.		13.0	1 lb. 2 oz.	1 lb. 8 oz.	1.92
16	1 lb. 4 oz.		13.0	1 lb. 4 oz.	2 lbs.	.92
17	1 lb. 6 oz.		13.0	1 lb. 6 oz.	2 lbs.	2.20
18	1 lb. 8 oz.		13.0	1 lb. 8 oz.	2 lbs. 8 oz.	.80
19	1 lb. 10 oz.		13.0	1 lb. 10 oz.	3 lbs.	1.20
20	1 lb. 12 oz.		13.0	1 lb. 12 oz.	3 lbs.	2.70
21	1 lb. 14 oz.		13.0	1 lb. 14 oz.	3 lbs.	.86
22	2 lbs.		13.0	2 lbs.	3 lbs.	3.07
23	2 lbs.		13.0	2 lbs. 8 oz.	3 lbs. 8 oz.	.50
24	2 lbs.		13.0	2 lbs. 8 oz.	4 lbs.	1.57
Total for 24 weeks	149.6 lbs.	686.	1453.9	164.5 lbs.	224 lbs.	
Cost....	$1.94	$27.44	$14.53	$3.29	$ .92	
Total Cost for 24 Weeks..						$48.02
Average Cost a Week..						$ 2.00

Calf No. 17, Holstein bull, dropped August 30, 1920, weighed 79 pounds at birth. He was larger and six days younger than his half brother—No. 15. He was fed and managed exactly in the same way as No. 15, except that he received molasses.

He received on the average of about 15½ ounces a day, beginning the fourth week with 2 ounces a day and gradually increasing until the end of the twenty-third week when he was receiving 2 pounds a day.

He was in excellent condition through the entire period of twenty-three weeks, except on September 29, when his bowels were a little loose. He made steady gains, except during the fourth week, and at that time he lost an average of 1.85 pounds a day. His daily average gain for the twenty-three weeks was 1.43 pounds.

CALF No. 18 (Holstein)

Date of Birth, September 13, 1920. **Weight at Birth 91 lbs.**

Average daily quantity of molasses, milk, silage, grain, and gain in weight.

Week	lbs. Molasses	lbs. MILK		lbs. Grain	lbs. Silage	lbs. Gain in Weight
		Whole	Skim			
1		13.				.62
2		13.				.85
3	2 oz.	12.		4 oz.		1.14
4	2 oz.	11.5		4 oz.		.93
5	2 oz.	12.3		6 oz.		.93
6	4 oz.	8.5	4.5	6 oz.	4 oz.	1.35
7	6 oz.	4.8	8.2	8 oz.	6 oz.	1.43
8	8 oz.		13.0	8 oz.	8 oz.	.93
9	10 oz.		13.0	12 oz.	12 oz.	1.93
10	12 oz.		13.0	12 oz.	12 oz.	1.21
11	14 oz.		13.0	16 oz.	16 oz.	1.70
12	16 oz.		13.0	16 oz.	1 lb.	.80
13	1 lb. 2 oz.		13.0	1 lb. 2 oz.	1 lb. 8 oz.	1.20
14	1 lb. 4 oz.		13.0	1 lb. 4 oz.	2 lbs.	.70
15	1 lb. 6 oz.		13.0	1 lb. 6 oz.	2 lbs.	2.30
16	1 lb. 8 oz.		13.0	1 lb. 8 oz.	2 lbs. 8 oz.	1.00
17	1 lb. 10 oz.		13.0	1 lb. 10 oz.	2 lbs. 8 oz.	1.57
18	1 lb. 12 oz.		13.0	1 lb. 12 oz.	2 lbs. 8 oz.	1.85
19	1 lb. 14 oz.		13.0	1 lb. 14 oz.	2 lbs. 8 oz.	1.70
20	2 lbs.		13.0	2 lbs.	3 lbs.	1.14
21	2 lbs.		13.0	2 lbs. 8 oz.	3 lbs.	2.36
22	2 lbs.		13.0	2 lbs. 8 oz.	3 lbs. 8 oz.	1.64
23	2 lbs.		13.0	2 lbs. 8 oz.	3 lbs. 8 oz.	2.86
24	2 lbs.		13.0	2 lbs. 8 oz.	4 lbs.	2.30
Total for 24 weeks	404 lbs.	75.10	233.78	452 oz.	594 oz.	
	176 lbs.	525.7	1635.9	197.7 lbs.	245 lbs.	
Cost....	$2.29	$21.02	$16.35	$3.95	$1.21	
Total Cost for 24 Weeks..						$44.92
Average Cost a Week..						$ 1.87

Calf No. 18, Holstein heifer, dropped August 13, 1920, weighed 91 pounds at birth. She was an average sized calf but had a rather weak constitution. She was fed and managed about like No. 17, except that she was fed molasses and changed to skim-milk somewhat earlier than either No. 15 or No. 17.

She was fed an average of about 13¼ ounces of molasses a day, beginning the third week and gradually increasing it until the end of the twenty-third week, when she was receiving 2 pounds a day.

This calf did not stay in the best of condition during the experiment. Her bowels were very loose on September 29, October 7 and 9, and again on October 13, caused by some digestive disturbance. On March 5 and 7 she was off feed.

Her weekly average gains were somewhat unsteady, but at the same time she increased slightly in weight every week. Her daily average gain was 1.4 pounds.

CALF No. 20 (Jersey)

Date of Birth, September 29, 1920. **Weight at Birth 50 lbs.**

Average daily quantity of molasses, milk, silage, grain, and gain in weight.

Week	lbs. Molasses	lbs. MILK Whole	lbs. MILK Skim	lbs. Grain	lbs. Silage	lbs. Gain in Weight
1		10.0				1.00
2		10.0				1.00
3		10.0				1.00
4		10.0				.70
5		7.4				.21*loss*
6		9.2				.70
7	2 oz.	10.0		4 oz.		.80
8	2 oz.	10.0		4 oz.		1.14
9	4 oz.	10.0		4 oz.		1.30
10	6 oz.	10.0		8 oz.		.50
11	8 oz.	10.0		10 oz.		1.21
12	10 oz.	10.0		12 oz.		1.07
13	12 oz.	10.0		14 oz.		1.36
14	14 oz.	10.0		14 oz.	4 oz.	1.00
15	1 lb.	9.7	.3	1 lb.	4 oz.	1.43
16	1 lb.	1.5	8.5	1 lb. 2 oz.	8 oz.	.70
17	1 lb.		10.0	1 lb. 4 oz.	8 oz.	1.07
18	1 lb.		10.0	1 lb. 6 oz.	8 oz.	1.07
Total for 18 weeks	53.3 lbs.	1034.6	201.7	64 lbs.	14 lbs.	
Cost....	$ .69	$41.38	$ 2.01	$1.28	$ .075	
Total Cost for 18 Weeks........						$45.46
Average Cost a Week........						$ 2.52

Calf No. 20, a Jersey heifer, dropped September 29, 1920, weighed 50 pounds at birth. She was about an average sized calf, but rather delicate.

This calf received an average of about 10 ounces of molasses a day for twelve weeks, beginning on the seventh week with 2 ounces a day and gradually increasing it until the end of the eighteenth week when she was receiving 1 pound a day.

On October 30, November 2, and November 17, her bowels were loose; the first time she was given medicine prescribed by a veterinarian, while at the other two periods, she was given the regular treatment of castor oil.

She grew to be one of the best calves in the lot. She showed good steady gains throughout the entire period, except the fifth week when she was sick and lost an average of .21 pound a day. Her daily average gain for the eighteen weeks was .93 pound.

CALF No. 23 (Jersey)

Date of Birth, October 15, 1920. Weight at Birth 48 lbs

Average daily quantity of molasses, milk, grain, silage, and gain in weight.

Week	lbs. Molasses	lbs. MILK		lbs. Grain	lbs. Silage	lbs. Gain in Weight
		Whole	Skim			
1		12.0				1.00
2		12.0				.93
3		12.0				.93
4		12.0				1.21
5	2 oz.	12.0		4 oz.		1.21
6	2 oz.	12.0		4 oz.		1.14
7	4 oz.	12.0		4 oz.		.70
8	6 oz.	11.4		6 oz.		1.30
9	8 oz.	12.0		8 oz.		1.50
10	10 oz.	12.0		10 oz.		1.36
11	12 oz.	12.0		12 oz.		1.14
12	14 oz.	12.0		14 oz.		.70
13	1 lb.	12.0		1 lb.	4 oz.	1.86
14	1 lb.	12.0		1 lb.	8 oz.	1.36
15	1 lb.	11.3	.7	1 lb. 2 oz.	8 oz.	1.36
16	1 lb.	4.0	8.0	1 lb. 2 oz.	8 oz.	1.00
17	1 lb. 4 oz.		12.0	1 lb. 4 oz.	1 lb.	1.43
Total for 17 weeks	62 lbs.	1278.	144.9	65.6 lbs.	19 lbs.	
Cost....	$ .80	$51.12	$ 1.44	$1.31	$ .9	
Total Cost for 17 Weeks..........						$54.76
Average Cost a Week..........						$ 3.22

Calf No. 23, a Jersey heifer, dropped October 15, 1920, weighed 48 pounds at birth. She was an average calf with a strong constitution.

She was fed an average of about 11 ounces of molasses a day, beginning with 2 ounces the fifth week and gradually increasing it until she was receiving 20 ounces a day at the end of the seventeenth week. Her bowels were loose on December 2 and again on the tenth. She was given 3 table-spoonfuls of castor oil followed with an antiseptic.

This calf remained in fine physical condition throughout the test and at the close was one of the best calves in the lot.

Her weekly average gains were quite steady, making a daily average of 1.18 pounds for the period of seventeen weeks.

CALF No. 24 (Jersey)

Date of Birth, October 24, 1920. **Weight at Birth 51 lbs.**

Average daily quantity of molasses, milk, grain, silage, and gain in weight.

Week	lbs. Molasses	lbs. MILK		lbs. Grain	lbs. Silage	lbs. Gain in Weight
		Whole	Skim			
1		10.0				1.00
2		10.0				.86
3	2 oz.	10.0		2 oz.		1.00
4	2 oz.	10.0		4 oz.		.70
5	4 oz.	10.0		4 oz.		1.30
6	6 oz.	10.0		6 oz.		.93
7	8 oz.	10.0		8 oz.		.93
8	10 oz.	10.0		10 oz.		1.00
9	12 oz.	10.0		12 oz.		1.00
10	14 oz.	10.0		14 oz.	4 oz.	.86
11	16 oz.	10.0		1 lb.	4 oz.	1.00
12	1 lb.	10.0		1 lb.	8 oz.	1.00
13	1 lb.	8.4	1.6	1 lb. 2 oz.	8 oz.	.86
14	1 lb.	1.6	8.4	1 lb. 2 oz.	8 oz.	.86
15	1 lb.		11.0	1 lb. 4 oz.	1 lb.	1.14
Total for 15 weeks	60.3 lbs.	910.	147.	64.8 lbs.	21 lbs.	
Cost....	$ .78	$36.40	$ 1.47	$1.29	$ .10	
Total Cost for 15 Weeks..........						$40.04
Average Cost a Week..........						$ 2.66

Calf No. 24, a Jersey heifer, dropped October 24, 1920, weighed 51 pounds at birth. This was an average sized calf with a strong constitution.

She was fed an average of 9 ounces of molasses a day, beginning with 2 ounces a day on the third week and gradually increasing it until at the end of the fifteenth week she was receiving 1 pound a day. She was never sick nor off feed during the test.

She was in excellent condition during the entire period. Her weekly average gains were steady, and made a daily average of .96 pounds.

CALF No. 26 (Holstein)

Date of Birth, November 7, 1920. **Weight at Birth 70 lbs.**

Average daily quantity of molasses, milk, grain, silage, and gain in weight.

Week	lbs. Molasses	lbs. MILK		lbs. Grain	lbs. Silage	lbs. Gain in Weight
		Whole	Skim			
1		10.0				.70
2	2 oz.	10.0		4 oz.		1.30
3	4 oz.	10.0		4 oz.		.30
4	6 oz.	10.0		4 oz.		.93
5	8 oz.	10.0		6 oz.		.93
6	10 oz.	10.0		6 oz.		1.30
7	12 oz.	10.0		8 oz.		1.30
8	12 oz.	10.0		8 oz.	4 oz.	1.14
9	14 oz.	10.0		10 oz.	4 oz.	1.00
10	14 oz.	10.0		12 oz.	8 oz.	1.43
11	14 oz.	9.7	.3	14 oz.	8 oz.	.93
12	1 lb.	3.6	6.4	1 lb.	8 oz.	.50
13	1 lb.		10.0	1 lb.	1 lb.	2.40
Total for 13 weeks	56 lbs.	793.1	116.9	47.2 lbs.	21 lbs.	
Cost....	$ .72	$31.72	$ 1.17	$ .94	$ .10	
Total Cost for 13 Weeks..............						$34.65
Average Cost a Week..............						$ 2.66

Calf No. 26, a Holstein heifer, dropped November 7, 1920, weighed 70 pounds at birth. This calf was a little below the average for a Holstein but was strong and vigorous.

She was fed molasses while very young. She received an average of 9.8 ounces a day for twelve weeks, beginning with 2 ounces a day the second week, and gradually increasing it until at the end of the thirteenth week she was receiving 1 pound a day.

She was never sick nor off feed; was in excellent condition throughout the test, especially at the close.

Her weekly average gains were a little unsteady but were gradual. She made an average daily gain of 1.09 pounds for the thirteen weeks.

CALF No. 14 (Jersey)

Date of Birth, August 23, 1920. **Weight at Birth 55 lbs.**

Average daily quantity of molasses, milk, silage, grain, and gain in weight.

Week	lbs. Molasses	lbs. MILK		lbs. Grain	lbs. Silage	lbs. Gain in Weight
		Whole	Skim			
1		10.				.8
2		10.				.3
3		10.				.857
4		9.				.21
5		9.3		4 oz.		1.64
6		10.0		4 oz.		1.50
7		10.0		6 oz.		.93
8		7.0	3.0	8 oz.	4 oz.	1.14
9		4.5	5.5	8 oz.	6 oz.	1.21
10			10.0	8 oz.	8 oz.	1.50
11			10.0	12 oz.	12 oz.	.80
12			10.0	12 oz.	12 oz.	1.80
13			10.0	1 lb.	1 lb.	1.14
14			10.8	1 lb.	1 lb.	1.20
15			12.0	1 lb. 2 oz.	1 lb. 8 oz.	2.00
16			12.0	1 lb. 4 oz.	2 lb.s	.07
17			12.	1 lb. 6 oz.	2 lbs.	1.93
18			12.	1 lb. 8 oz.	2 lbs. 8 oz.	.50
19			12.	1 lb. 10 oz.	2 lbs. 8 oz.	1.60
20			12.	1 lb. 12 oz.	2 lbs. 8 oz.	1.90
21			12.	1 lb. 14 oz.	3 lbs.	1.00
22			12.	2 lbs.	3 lbs.	1.14
23			12.	2 lbs.	3 lbs.	1.14
24	24 oz.		12.	2 bs.	3 lbs.	2.30
Total for 24 weeks		558.6	1254.1	157 lbs.	207 lbs.	
Cost....	$ .02	$22.34	$12.54	$3.14	$1.03	
Total Cost for 24 Weeks......						$39.07
Average Cost a Week......						$ 1.62

Calf No. 14, a Jersey heifer, dropped August 23, 1920, weighed 55 pounds at birth. This was an average sized calf, strong and healthy.

This calf received no molasses during the test. On September 21, she developed a case of scours and was sick for four days, but not off feed. She was again scouring on the twenty-ninth. Her milk was reduced and she was given 3 table-spoonfuls of castor oil.

During the remaining part of her test, she was in good physical condition. Her average daily gain for the twenty-three weeks was 1.14 pounds.

CALF No. 27 (Holstein)

Date of Birth, November 28, 1920. **Weight at Birth 94 lbs.**

Average daily quantity of molasses, milk, grain, silage, and gain in weight.

Week	lbs. Molasses	lbs. MILK		lbs. Grain	lbs. Silage	lbs. Gain in Weight
		Whole	Skim			
1		12.0				1.43
2		12.0				1.00
3		12.0		4 oz.		1.14
4		12.0		6 oz.		1.00
5		12.0		8 oz.	4 oz.	.60
6		12.0		10 oz.	4 oz.	.70
7		12.0		12 oz.	4 oz	.93
8		11.7	.3	14 oz.	8 oz.	1.50
9		5.6	6.4	14 oz.	8 oz.	1.60
10			12.0	1 lb.	1 lb.	1.80
Total for 10 weeks		709.1	130.9	36.7 lbs.	18 lbs.	
Cost....		$28.36	$ 1.31	$ .73	$ .09	
Total Cost for 10 Weeks..........						$30.49
Average Cost a Week..........						$ 3.05

Calf No. 27, a Holstein bull, dropped November 28, 1920, weighed 94 pounds at birth. This was a good sized calf, strong and well developed. Was never sick nor off fed and received no molasses during the test.

At the close of the test he was in good physical condition; his daily average gain was 1.17 pounds.

CALF No. 19 (Jersey)

Date of Birth, September 29, 1920. **Weight at Birth 50 lbs.**

Average daily quantity of molasses, milk, grain, silage, and gain in weight.

Week	lbs. Molasses	lbs. MILK		lbs. Grain	lbs. Silage	lbs. Gain in Weight
		Whole	Skim			
1		10.0				1.00
2		10.0				1.00
3		10.0				1.00
4		8.3				.70*loss*
5		6.4				.30*loss*
6		6.0				.07
7		9.0		4 oz.		1.07
8		10.0		4 oz.		.80
9		10.0		4 oz.		.93
10		10.0		8 oz.		1.30
11		10.0		10 oz.		1.21
12		10.0		12 oz.		1.35
13		10.0		14 oz.		1.14
14		10.0		14 oz.	4 oz.	1.00
15		10.0		1 lb.	4 oz.	1.40
16		1.5	9.5	1 lb. 2 oz.	8 oz.	.57
17			10.0	1 lb. 4 oz.	8 oz.	2.07
18			10.0	1 lb. 6 oz.	8 oz.	1.57
19			10.0	1 lb. 8 oz.	12 oz.	.93
Total for 19 weeks		988.4	276.5	73.75	19 lbs.	
Cost....		$39.53	$ 2.76	$1.47	$ .09	
Total Cost for 19 Weeks....						$43.85
Total Cost a Week....						$ 2.30

Calf No. 19, a Jersey heifer, dropped September 29, 1920, weighed 50 pounds at birth. This was an average sized calf, but it had a weak constitution. She did very well for the first three weeks and drank as much as 10 pounds of milk a day.

At the beginning of the fourth week she developed a bad case of scours which nearly proved fatal. She continued in this condition for about three weeks, but her appetite was good all of the time.

She was fed no molasses, but was given about the same amount of grain as calves her size and age.

At the close of her test, she was in fine condition. Her gains were unsteady. She lost weight during the fourth and fifth weeks, and gained very little during the sixth week. Her daily average gains for the nineteen weeks was .81 pounds.

CALF No. 28 (Jersey)

Date of Birth, November 23, 1920. **Weight at Birth 60 lbs.**

Average daily quantity of molasses, milk, grain, silage, and gain in weight.

Week	lbs. Molasses	lbs. MILK		lbs. Grain	lbs. Silage	lbs. Gain in Weight
		Whole	Skim			
1		10.0				1.00
2		10.0		2 oz.		.80
3		10.0		4 oz.		.55
4		10.0		6 oz.		1.00
5		10.0		6 oz.		.86
6		10.0		8 oz.	4 oz.	1.00
7		10.0		10 oz.	4 oz.	.70
8		10.0		12 oz.	8 oz.	1.00
9		10.0		14 oz.	8 oz.	.70
10		10.0		14 oz.	8 oz.	.86
11		10.0		14 oz.	1 lb.	.86
Total for 11 weeks		770.		40 lbs.	21 lbs.	
Cost....		$30.80		$ .80	$ .10	
Total Cost for 11 Weeks..						$31.70
Total Cost a Week..						$ 2.88

Calf No. 28, a Jersey heifer, dropped November 23, 1920, weighed 60 pounds at birth. This was an average sized calf, strong and vigorous.

This calf received no molasses during the eleven weeks of her feeding test; was never sick nor off feed.

She was in good physical condition at the close of the test, her daily average gain was .85 pound.

CALF No. 22 (Holstein)

Date of Birth, October 13, 1920. **Weight at Birth 89 lbs.**

Average daily quantity of molasses, milk, silage, grain, and gain in weight.

Week	lbs. Molasses	lbs. MILK		lbs. Grain	lbs. Silage	lbs. Gain in Weight
		Whole	Skim			
1		12.5				.86
2		13.7				1.00
3		14.0				1.50
4		14.0				1.21
5		14.0		4 oz.		1.00
6		14.0		4 oz.		1.86
7		14.0		4 oz.		1.80
8		14.0		8 oz.		1.36
9		14.0		10 oz.		1.70
10		14.0		12 oz.		1.00
11		14.0		14 oz.		1.60
12		14.0		1 lb.	4 oz.	1.14
13		14.0		1 lb. 2 oz.	4 oz.	1.64
14		14.0		1 lb. 2 oz.	8 oz.	1.86
15		13.3	.7	1 lb. 4 oz.	8 oz.	1.07
16		7.5	6.5	1 lb. 6 oz.	8 oz.	1.86
17			14.0	1 lb. 8 oz.	12 oz.	2.10
Total for 17 weeks		1505.0	148.4	76.2 lbs.	13 lbs.	
Cost....		$60.20	$ 1.48	$1.52	$ .06	
Total Cost for 17 Weeks..........						$63.28
Average Cost a Week..........						$ 3.72

Calf No. 22, a Holstein heifer, dropped October 13, 1920, weighed 98 pounds at birth. She was a very strong calf, and showed good capacity to handle feed. She received no molasses during the seventeen weeks of her feeding test.

She received more milk and grain according to age than any other calf used in the experiment, and was in excellent condition throughout the entire period, except on January 7 her bowels were a little loose.

Her daily average gain for the seventeen weeks was 1.445 pounds.

CALF No. 15 (Holstein)

Date of Birth, August 24, 1920. **Weight at Birth 65 lbs.**

Average daily quantity of molasses, milk, grain, silage, and gain in weight.

Week	lbs. Molasses	lbs. MILK		lbs. Grain	lbs. Silage	lbs. Gain in Weight
		Whole	Skim			
1		10.8				1.8
2		12.0				.86
3		12.0				1.00
4		12.0		4 oz.		.71
5		11.5		4 oz.		1.59
6		12.5		4 oz.		1.09
7		12.5		6 oz.		2.14
8		8.5	4.5	8 oz.	4 oz.	.85
9		4.8	8.2	8 oz.	6 oz.	1.36
10			13.0	8 oz.	8 oz.	1.80
11			13.0	12 oz.	12 oz.	2.07
12			13.0	12 oz.	12 oz.	1.85
13			13.0	1 lb.	1 lb.	1.43
14			13.0	1 lb.	1 lb.	2.07
15			13.0	1 lb. 2 oz.	1 lb. 2 oz.	1.43
16			13.0	1 lb. 4 oz.	2 lbs.	.85
17			13.0	1 lb. 6 oz.	2 lbs.	2.64
18			13.0	1 lb. 8 oz.	2 lbs. 8 oz.	1.14
19			13.0	1 lb. 10 oz.	3 lbs.	1.80
20			13.0	1 lb. 12 oz.	3 lbs.	1.93
21			13.0	1 lb. 12 oz.	3 lbs.	.57
22			13.0	2 lbs.	3 lbs.	3.07
23			13.0	2 lbs. 8 oz.	3 lbs. 8 oz.	1.93
24	2 lbs.		13.0	2 bs. 8 oz.	4 lbs.	2.00
Total for 24 weeks		67.72	1453.9	164.5 lbs.	222 lbs.	
Cost....		$27.04	$14.53	$3.29	$1.11	
Total Cost for 24 Weeks..........						$45.97
Average Cost a Week						$ 1.91

Calf No. 15, a Holstein bull, dropped August 24, 1920, weighed 65 pounds at birth. He was a little below the average for a Holstein, but was strong and vigorous.

This calf received no molasses during the test. On September 29, he developed a case of scours. The milk was reduced to about one-half, and he was given 4 table-spoonfuls of castor oil. On October 5 and again on the twelfth a similar condition occurred and the same treatment was given.

On January 22, he was constipated, was sluggish and sleepy, and would not eat nor drink.

At the close of the period of twenty-three weeks of feeding he was in good physical condition, showed good growth and development. His average daily gain in weight for the entire period of twenty-three weeks was 1.56 pounds.

CALF No. 25 (Jersey)

Date of Birth, October 31, 1920. **Weight at Birth 50 lbs.**

Average daily quantity of molasses, milk, grain, silage, and gain in weight.

Week	lbs. Molasses	lbs. MILK		lbs. Grain	lbs. Silage	lbs. Gain in Weight
		Whole	Skim			
1		10.0				1.00
2		10.0				.93
3		10.0		4 oz.		.86
4		10.0		4 oz.		.14
5		10.0		6 oz.		1.21
6		10.0		6 oz.		.93
7		10.0		6 oz.		.70
8		10.0		8 oz.		1.50
9		10.0		10 oz.	4 oz.	.86
10		10.0		12 oz.	4 oz.	.93
11		10.0		12 oz.	8 oz.	1.30
12		9.6	.4	14 oz.	8 oz.	.70
13		3.7	6.3	1 lb.	1 lb.	1.43
Total for 13 weeks		865.9	46.9	42.8 lbs.	17 lbs.	
Cost....		$34.63	$ .46	$ .85	$ .08	
Total Cost for 13 Weeks..						$36.02
Average Cost a Week..						$ 2.77

Calf No. 25, a Jersey heifer, dropped October 31, 1920, weighed 50 pounds at birth. This was an average calf but it did not appear to be very strong.

This calf received no molasses during the test. Her bowels were loose on November 17, when she was given 3 table-spoonfuls of castor oil. She was never off feed and had a good appetite throughout the entire period of fifteen weeks.

At the close of the test she was in excellent condition. Her daily average gain was .88 pound.

WITH MOLASSES

No.	Weight	Feed	Cost
16 Jersey	50 lbs.	24 Weeks	$41.29
17 Holstein	79 "	24 "	47.98
18 Holstein	91 "	24 "	44.72
20 Jersey	50 "	18 "	45.45
23 Jersey	48 "	17 "	47.38
24 Jersey	51 "	15 "	38.10
26 Holstein	70 "	13 "	34.65
Total		135 Weeks	$299.53
Average Cost a Week			$ 2.21
Average Gain a Week			1.14 lbs.

WITHOUT MOLASSES

No.	Weight	Feed	Cost
14 Jersey	55 lbs.	24 Weeks	$38.75
27 Holstein	94 "	10 "	39.49
19 Jersey	50 "	19 "	43.85
28 Jersey	60 "	11 "	31.70
22 Holstein	89 "	17 "	62.56
15 Holstein	65 "	24 "	45.90
25 Jersey	50 "	13 "	35.94
Total		118 Weeks	$298.17
Average Cost a Week			$ 2.52
Average Gain a Week			1.12 lbs.

VALUES OF FEED

Grain Feed	$ 40.00 ton
Molasses	7.00 per bbl.
Whole Milk	4.00 per 100 lbs.
Skimmed Milk	1.00 per 100 lbs.
Silage	10.00 per ton

The hay that was fed to calves was not weighed and not included in cost.

Nine Jersey heifer calves sired by Noble's Raleigh Fairy Boy 144515, owned by the Louisiana State University. These calves were among those used in the molasses feeding experiment.

AUGUST, 1921 LOUISIANA BULLETIN NO. 181

LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE

AGRICULTURAL EXPERIMENT STATIONS

W. H. DALRYMPLE, DEAN AND DIRECTOR.

BATON ROUGE, LOUISIANA

E. C. Auchter

THE MOSAIC DISEASE OF THE IRISH POTATO AND THE USE OF CERTIFIED POTATO SEED

BY
C. W. EDGERTON,
PLANT PATHOLOGIST
AND
G. L. TIEBOUT,
HORTICULTURIST

The Mosaic Disease of the Irish Potato and the use of Certified Potato Seed.

C. W. EDGERTON AND G. L. TIEBOUT.

The disease of Irish potatoes, known as the mosaic disease, or sometimes locally as the curly leaf, is the most important potato disease in Louisiana. It occurs in every section of the State where the Bliss Triumph variety is grown and frequently causes a very heavy loss. A loss of fifty per cent or more is not at all uncommon and occasionally the crop in some fields is a total failure. During the season of 1921, a great many growers did little better than to get their seed back.

APPEARANCE OF THE DISEASE.

The appearance of the mosaic disease varies to some extent, depending upon the season, severity of the attack and other factors. Two forms or stages of the disease are commonly recognized, these being commonly known as the curly leaf stage and the dwarf stage. These are not distinct forms, however, as there are intermediate stages between them.

The most characteristic symptom of the disease is the curly or uneven appearance of the leaves (Fig. 1). There may be slightly raised blister-like areas on the leaves or there may be merely an uneven, curly or wavy appearance to the leaf surface. In most cases, the raised portions are darker green in color than the rest of the surface, this giving the leaf more or less of a mottled appearance. This mottling, however, is not always evident.

The leaves of affected plants are also generally slightly lighter in color than those of healthy ones. In a badly infected field, the light color is usually evident by looking across the field. Mosaic plants also have other characters which are noticeable after one becomes acquainted with the disease. The leaves on affected plants are usually smaller and generally stand more upright than on healthy ones and the whole plant has a more open appearance. Plants with the curly leaf stage of the disease may often be as large as healthy ones; such a plant is shown in Fig. 2. In the dwarf stage, however, the internodes between the leaves are much shortened, the leaves are small and the whole plant remains small and dwarfed. It is the dwarf stage that usually attracts the notice of the grower. Plants in the dwarf stage produce only a few small, unmarketable tubers. Plants in the curly leaf stage produce some good tubers but the yield is much less than with healthy plants.

The loss from mosaic seems to be much greater in Louisiana than in the northern potato-growing districts. This is probably due to the higher temperature. It is a well recognized fact that if there is any mosaic infection in the seed, the disease will quickly show up when potatoes are planted in the South. In the northern states, there are records of high yields even with a considerable mosaic infection, but this is not the case in the South. The plants seem to be weakened by the disease and the hot weather causes them to go to pieces. Frequently in hot weather, the leaf tissue of affected plants will break down and die while no such condition is noticed on healthy plants.

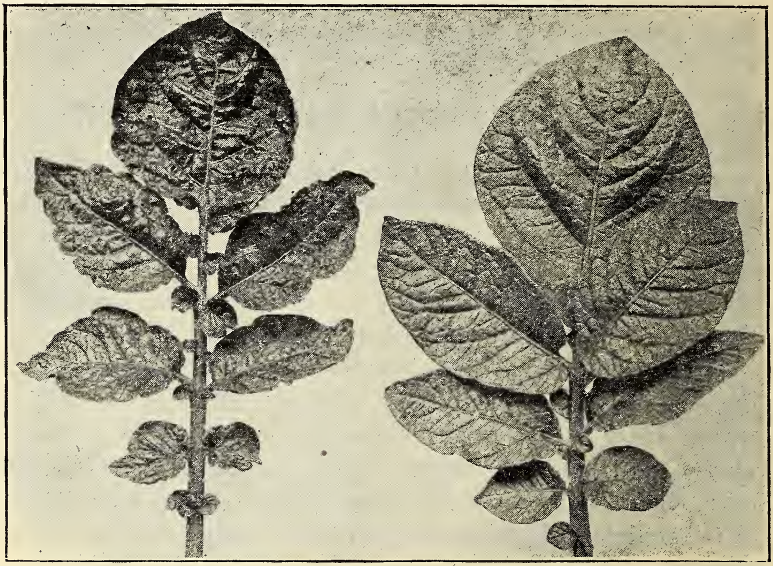

Figure 1. On the left, a potato leaf affected with the mosaic disease; on the right, a healthy leaf.

The temperature also has an effect on the appearance of the disease. Often in the cool early spring, affected leaves will have a very decided mottled appearance, while this is very rare later in the season. During the warm weather, late in the season, the leaves only show the pale color and the curly effect.

THE MOSAIC DISEASE IN LOUISIANA.

The mosaic disease has been known in Louisiana for a considerable period. Specimens of the dwarf stage were noticed in a field at Baton Rouge in 1909. This was before the time that the mosaic was recognized as a disease. At that time, it was thought that the dwarfing was due to a deterioration or running out of the seed. It is probable that the disease has been in the state for a much longer period.

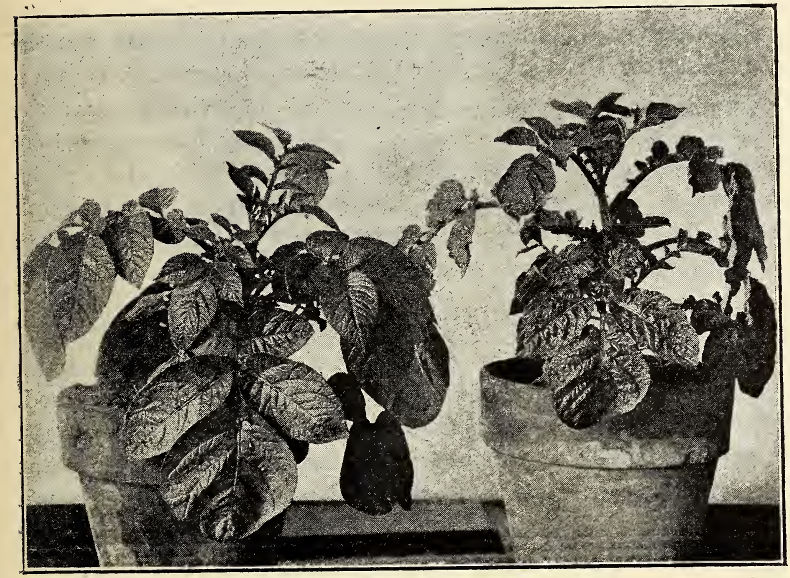

Figure 2. On the right, a potato plant affected with the mosaic disease; on the left a healthy plant. These plants were transplanted from the field just before the photographs were made.

VARIETIES AFFECTED.

Different potato varieties show a marked difference in regard to their susceptibility to the mosaic disease. Some varieties are very susceptible and are injured very badly, while other varieties are not affected at all or at least but slightly. Of the varieties grown in Louisiana, the Bliss Triumph is the only one that is seriously affected. Other varieties like the the Irish Cobbler, White Star and Burbank are not injured by the mosaic. The Bliss Triumph, however, is used to a greater extent in Louisiana than any other variety. It is an excellent early market potato and if it were not for the mosaic, it would be almost an ideal variety for Louisiana conditions. It is earlier, yields better and sells better than the other varieties which have been tried.

It may be that the ultimate solution of the mosaic problem will be the complete elimination of the Triumph potato. In the Bayou Lafourche region, this has already practically been accomplished. Formerly in that region, the Triumph was the principal potato, but on account of the heavy losses caused by the disease, the growers gradually replaced it with white varieties which are immune to the disease. However, the Triumph potato has so many good qualities that it would be unwise to stop growing it if there is any other solution to the problem.

CAUSE AND DISSEMINATION OF THE MOSAIC DISEASE.

The cause of the mosaic disease has never been discovered. It is like a number of human and animal diseases in this respect. A great deal is known about how it acts and spreads from plant to plant but no one has been able to determine the actual cause. The disease is very contagious or infectious. Under favorable conditions, the disease spreads very rapidly from plant to plant. A little juice from an infected plant placed in the tissues of a healthy plant under the right conditions, will result in a mosaic infection.

Apparently after a plant once becomes affected it always remains affected. As far as is known, it never outgrows the infection or becomes immunized to it. Furthermore, the tubers which develop on an infected plant, contain the disease and if these tubers are planted the young plants which develop from them will be infected.

Under ordinary field conditions, the disease seems to be largely transmitted by insects. Sucking insects, such as plant lice, feed upon diseased plants and then fly to healthy plants, carrying the infection with them.

PRIMARY AND SECONDARY INFECTIONS.

With the mosaic diseases like the potato mosaic, it is usual and important to distinguish between what are called primary and secondary infections. A plant that receives the disease from the infected seed piece is said to have a primary infection. The disease shows on the plant when it first comes through the ground and stays with it through the whole season.

A plant growing from a healthy seed-piece and healthy when it comes through the ground but later becoming infected during the growing season, is said to have a secondary infection. With secondary infections, the disease only shows on those leaves that develop after the plants become infected. Under Louisiana field conditions, it is usually possible to recognize the plants with secondary infections as the basal or bottom leaves will be perfectly healthy while the upper leaves will show the mosaic or curly appearance.

There is a marked difference in the yield of plants with primary and secondary infections. Usually secondary infections do not decrease the yield to any marked extent, most of the reductions in yield being due to primary infections. Consequently, the secondary infections do not matter to the Louisiana grower unless he expects to use the tubers for planting a fall crop.

Many growers make a practice of growing a fall crop from potatoes they have raised in the spring and then using the tubers grown in the fall for the main planting the following spring. This system has given very good results in some instances but all growers recognize that the strains soon run out. They have found by experience that it is necessary to discard their home seed after a year or two and bring in fresh seed from the northern states. The main reason for the running out seems to be the increased infection of mosaic. Fields of potatoes raised from home-grown seed in the Alexandria district during 1921 had mosaic infections ranging from fifty to ninety-five per cent. The fields with mosaic of ninety per cent or more, made practically nothing.

MOSAIC CONDITION OF COMMERCIAL UNCERTIFIED SEED.

The Louisiana grower of Triumph potatoes has been working under a considerable handicap because he has had to depend largely upon northern grown potatoes for his seed. As there is no way of telling the mosaic in the tubers, he has been compelled to buy seed potatoes on the market and trust to luck that they were not too badly affected with the mosaic; and too frequently, the luck has been against him. Only in the last few years, has it been possible to obtain any information about any seed on the market.

The common commercial uncertified seed which is shipped into Louisiana is, as a rule, extremely poor. Occasionally a good lot of seed finds its way into the state but it is the exception. Such a lot of good seed was obtained at Alexandria during 1921. Fields from this seed showed a mosaic infection of only about three to five per cent. Usually, however, the mosaic infection in uncertified seed runs from fifty to ninety per cent. If the Louisiana grower is forced to buy his seed as he has in the past without knowing anything about it, it will be much better for him to discard the Triumph potato entirely and substitute some variety that is known to be resistant to the mosaic disease. The only hope for the Triumph potato in Louisiana in some system of certification that will enable the grower to know exactly what he is buying.

CERTIFIED POTATO SEED.

During the past few years, some of the northern states have been putting on the market what is called certified seed. As some of the Louisiana growers were severely disappointed with some of this seed, during 1921, partly due to a misunderstanding and partly due to the difficulties involved in the certification itself, it is necessary to explain carefully what is meant by certified seed.

The seed certification work was started in the state of Wisconsin several years ago, under the direction of Professor J. G. Milward of the Wisconsin State University and Experiment Station. It was the object of the work to improve the different varieties and put upon the market the best seed that could be produced. Since the work was started in Wisconsin, other states have also taken it up. There have been many difficulties encountered in the work and today it is still far from perfect. Yet the possibilities of the work are plainly apparent.

Certified seed is grown under a system of inspection. The plants are carefully inspected in the field during the growing season and then the tubers are inspected in the bin after they are dug. There are certain standards that the potatoes have to reach. If they pass these standards the owner is given a certificate. Upon this certificate is given the health condition of the plants, the relative amount of any disease that may be present, and also information regarding trueness to type and other points of interest in the seed improvement work. These potatoes are not guaranteed to be free of any disease but the amount of any disease found by the inspectors is given in the certificate. Potatoes can have as much as thirty or forty per cent of the mosaic and still be given a certificate and sell as certified seed. Potatoes with a mosaic percentage above this, however, are not usually given a certificate. There are many points considered in the inspection work but from the standpoint of the Louisiana grower, the mosaic percentage seems to be one of the most important. Some of the Louisiana growers have not understood just what is meant by certified seed. Some have had the idea that this seed is entirely free of mosaic and consequently they have been disappointed.

During the first few years, the seed certification work was carried on and conducted largely according to the views of the producer of the seed. There was no information to show that the standards set for the northern producer were the ones that were of particular interest to the southern grower. During that period, the Louisiana Experiment Station did not recommend certified seed very strongly and would not today if the authorities in the northern states had not modified their system. There was no evidence to show that the seed which was being certified was the best seed for southern conditions. During the past few years, however, under the direction of the United States Department of Agriculture, tests with certified seed have been made in a number of the southern states. Consequently, we have some ideas in regard to what may be expected from certified seed.

EXPERIMENTS WITH CERTIFIED SEED IN LOUISIANA.

During three years, certified and inspected lots of Triumph seed from various northern states, including Wisconsin, Minnesota, Nebraska, Michigan, Maine and other states, have been procured by the United States Department of Agriculture and sent to the Experiment Station at Baton Rouge for trial. From eight to twelve different lots of certified seed were received each year. For a check, the Experiment Station purchased on the open market four or five lots of uncertified seed from various dealers over the state. The object of the tests was to compare the certified seed with the ordinary commercial seed that the growers are in the habit of using.

It is expected that these experiments will run for five years before the complete results are published. Consequently, in this bulletin there will only be presented some general conclusions, which are more or less evident and should be known by the Louisiana grower. To make these conclusions clear, part of the results which were obtained during the season of 1921 are introduced below in tabular form. In this publication it is not necessary to give the results of the two preceeding years as they were very similar to those of 1921.

In 1921, eleven lots of certified seed were received and were planted with five lots of uncertified seed in seven different plots. The duplication of plots gave a check on the work and also permitted digging at different periods. In the table below are given the results from one of the plots. There is included the source of the seed, the mosaic percentage, the total yield per acre and the yield of No. 1 potatoes. With the certified seed, the source of seed refers to the state in which the potatoes were grown; with the uncertified seed to the city or town in Louisiana in which they were purchased. The mosaic percentage was obtained from counts made by Professor Wm. Stuart of the United States Department of Agriculture on April 18, about a month before the potatoes were dug. The mosaic percentage includes both primary and secondary infections.

TABLE 1.

Tests of certified and uncertified seed at Baton Rouge in 1921.

CERTIFIED SEED					UNCERTIFIED SEED				
Lot No.	Source of Seed	Yield, Bushels per Acre		Mosaic Percentage	Lot No.	Source of Seed	Yield, Bushels per Acre		Mosaic Percentage
		Total	No. 1 Grade				Total	No. 1 Grade	
7	Wisc.	225.0	187.8	18.5	13	Alexandria	177.5	149.8	6.4
10	Wisc.	220.0	190.5	10.9	14	Baton Rouge	123.2	69.0	36.1
1	Nebr.	216.4	187.5	9.6	12	New Orleans	114.3	79.9	78.7
9	Wisc.	213.7	184.8	9.3	16	Thibodaux	78.5	52.0	97.4
2	Nebr.	205.6	177.8	34.2	15	New Orleans	65.8	50.3	77.4
3	Nebr.	205.5	174.5	3.5					
6	Nebr.	190.3	154.0	28.1					
4	Nebr.	182.1	150.2	13.2					
11	Minn.	169.4	142.3	23.6					
5	Nebr.	161.7	136.1	10.9					
8	Wisc.	74.7	49.7	98.9					

There are several important things shown by the results in the table.

First. The amount of mosaic in the seed seems to be one of the important deciding factors in the productiveness of the strains. All the low yielding strains, whether certified or uncertified, showed a high percentage of mosaic, while all of the high yielding strains showed a low percentage of mosaic.

Second. Most of the lots of certified seed, which have been tried, have been considerably better than the ordinary commercial uncertified seed.

Third. Most of the uncertified lots of seed have been very poor, showing high percentages of mosaic and very low yields. However, good lots of this seed are sometimes obtained. Such a lot was the one obtained from Alexandria, during 1921, and shown in the table. However, out of the five lots of commercial seed, only one was good; all of the rest were extremely poor. The tests show that a grower is more than likely to obtain poor seed if he is forced to buy uncertified Triumph seed on the open market.

Fourth. Some lots of certified seed may break and be as poor as any of the ordinary uncertified seed. Such a lot, No. 8, is shown in the table, (See Fig. 3). It is such seed as this that has given and is liable to give certified seed a bad name. Yet of the eleven lots of certified seed, there was only one that was really bad. When this average is compared with the average obtained with the uncertified lots, it is seen that there is a much better chance of getting good seed from certified seed than from ordinary seed. Whether by any system of inspection the northern producers will be able to entirely eliminate these bad lots of seed is at present a question.

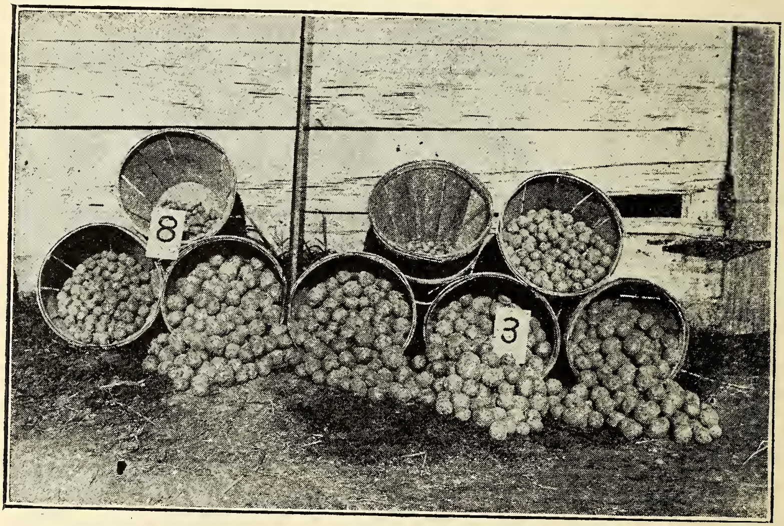

Figure 3. Potatoes dug from two rows planted with certified seed. The five hampers on the right were from one of the high yielding strains; while the three hampers on the left were from the very poor strain that showed a high percentage of mosaic.

Fifth. There is no direct evidence to show that any one part of the country can produce better seed than other parts. Of the lots producing more than 170 bushels to the acre of No. 1 potatoes, three came from Wisconsin and three from Nebraska. The results show that the regions represented by these two states can grow good Triumph seed.

From the above it would seem that the grower has a better chance of success by buying certified seed than by buying ordinary uncertified seed. The averages are certainly in favor of the certified seed. Yet the fact that seed are certified is not an assurance of success. Until the certification and inspection work becomes more nearly perfect there is always some chance of getting poor seed.

THE SMITH STRAIN OF SEED.

There has been another interesting development of the work. The Wisconsin authorities, watching the behavior of the Wisconsin grown potatoes in the southern experiments, have taken steps to discard all strains which are not high yielding and in other ways satisfactory. They have selected one of the best strains, now known as the Smith strain, and are placing this in the hands of the Wisconsin growers who are growing certified seed. It is interesting to note that the two lots of certified seed ranking first and second in the 1921 experiments at Baton Rouge were of this Smith strain. It would seem that if the Wisconsin growers are able to keep the mosaic percentage low, they will be able to make a permanent improvement in their certified seed by this method.

GROWERS' TESTS OF CERTIFIED SEED.

It is recognized that the supreme test of any seed is the test made by the users of that seed. Unfortunately, we do not have a great amount of information on that subject. Previous to 1921, there had been but little certified seed used in the State of Louisiana; consequently, practically all of our information comes from the 1921 trials. In 1921, a number of cars were shipped into the State and were distributed in various sections. Some of the results with this seed were good and some were decidedly bad.

In the Hammond region, a carload of certified seed, mostly of the Smith strain, was received and distributed to a great many growers. Without a known exception, every grower had excellent results. The potatoes had a very small percentage of mosaic; they grew vigorously and made high yields. The growers and dealers were very much pleased with the seed and expect to use certified seed next season.

In the Alexandria district, there was a different story. A number of carloads, all from the same man, were shipped to that point. On account of a misunderstanding, the growers did not ask for a certificate from the Wisconsin grower. They assumed that all certified seed were alike. As a matter of fact, these potatoes came from a Wisconsin field that showed a mosaic infection of thirty per cent in 1920. When these potatoes were planted in Louisiana, instead of having fields practically mosaic free, the growers found that their fields ran from seventy to eighty per cent of mosaic. The results were extremely disappointing. The highest yield obtained by any grower was twenty-six bushels to the acre, while the average yield was about ten bushels. A number of farmers did not have enough potatoes to dig. The Alexandria growers were extremely unfortunate in that they obtained a strain that broke—a strain similar to the No. 8 strain in the Baton Rouge test. To make the tests more striking, it happened that the uncertified seed that were shipped into the territory were exceptionally good. They were of the same lot of seed that did so well in the Baton Rouge test. Yields from these potatoes varied from seventy-five to one hundred and thirty bushels to the acre on five foot rows.

In the neighborhood of Ruston, some certified seed were received which, from reports, did very poorly. These potatoes also came from growers who had from thirty to fifty per cent of mosaic in their fields.

It is seen that the results which have been obtained by the growers are partly good and partly bad. All of the results show definitely that a greater consideration must be given the mosaic disease by the northern growers of certified seed if they expect to make this seed popular in the southern states.

RECOMMENDATIONS REGARDING CERTIFIED SEED.

In spite of some unfortunate disappointing results obtained by the Louisiana grower, the Louisiana Experiment Station recommends the use of this seed. While there is no guarantee with this seed that a good crop will be obtained, the averages are with it. Seventy-five to eighty-five per cent of the lots of certified seed which have been tried by the Experiment Station have been found to be good, while less than twenty per cent of the commercial uncertified seed has been in the same class. If this ratio is maintained, the grower has about four chances out of five of obtaining a good crop with certified seed, while with the uncertified seed he seems to have only about one chance out of five.

There are several things which the growers should look into, however, before purchasing the seed. In the first place, he should demand a strain that is known to be high yielding. If he buys in the Wisconsin region, he should demand the Smith strain. There are probably other strains in Wisconsin that are just as good but there is no definite information about them. Until the other strains are proved to be good, the Louisiana grower should take no chances, but should demand the Smith strain. According to Professor J. G. Milward, a considerable number of the Wisconsin growers are and will be using this strain.

In the second place, the Louisiana purchaser of certified seed should demand a copy of the certificate issued to the northern producers. Upon the certificate will be given the amount of mosaic found in the field in which the seed were grown. If the percentage of mosaic runs high, it should not be purchased. It is doubtful if seed are safe, if the mosaic percentage runs above ten or fifteen per cent.

It is believed that if these two points are looked into before purchasing seed, there will be a better chance of obtaining good seed. Yet, with all of these precautions, the growers must appreciate that we are only figuring on averages and there may be times when the seed that have all the appearances of being the best, may break and be as poor as any of the commercial strains. Yet it is firmly believed that these times will be far less frequent than they have been in the past with the uncertified seed which the growers have been forced to buy.

Certified seed should also be treated with formaldehyde for scab, just the same as uncertified seed. While certified seed usually contains only a small percentage of scab, there is always enough present to necessitate the formaldehyde treatment.

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LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE

AGRICULTURAL EXPERIMENT STATIONS

W. H. DALRYMPLE, DEAN AND DIRECTOR

BATON ROUGE, LOUISIANA

ONION DISEASES AND ONION SEED PRODUCTION

BY
C. W. EDGERTON,
PLANT PATHOLOGIST

ONION DISEASES AND ONION SEED PRODUCTION

C. W. EDGERTON

For a number of years onion diseases have been causing considerable injury in some sections of South Louisiana, being particularly severe in the Bayou Lafourche region, the most important onion section of the state. These troubles have been especially severe on the seed crop. Practically every year the seed crop has been reduced at least fifty per cent and often the reduction has been considerably more. The disease which seems to cause the most damage is the black stalk rot, though the onion mildew and some other troubles are also important.

The onion growers along Bayou Lafourche have long made a practice of growing their own seed. They have had to depend upon their own seed as they use almost exclusively a local variety, known as the Creole onion. Each grower usually has a few rows from which he obtains seed for his own planting. The onion is a comparatively heavy seed producer and it does not take a very large plot, even if the crop is reduced one-half by disease, to make sufficient seed to plant a considerable acreage. Consequently, in normal years with a normal acreage, the growers do not become seriously concerned with disease on their seed onions. However, it sometimes happens that when the price of onions goes up, resulting in an extension of the acreage planted, there is difficulty in obtaining sufficient seed. During the war, when onions went to a very high price, there was a heavy acreage increase and a very serious shortage of seed. Seed was in such demand that it went to as high as four dollars per pound. During that period some of the growers increased their acreage of seed onions to a considerable extent in order to furnish seed for the market, and for a period, were seriously concerned by the diseases. With the decline in price of onions since the war, the acreage has dropped back to normal, and the interest in the diseases has declined.

INVESTIGATION ON THE DISEASES.

During the war, practically as an emergency measure, some investigations were started on some of the important onion troubles. When the work was started, it was carried on jointly by the Department of Plant Pathology of the Experiment Stations, the Extension Division of the University and the U. S. Bureau of Entomology. D. C. Neal represented the Extension Division and T. H. Jones, the Bureau of Entomology. At the end of the first year the position of Extension Pathologist became vacant on account of the stoppage of the emergency appropriations. Also at that time the entomological department withdrew from the work because it was found that thrips had practically nothing to do with the onion seed failure. Consequently the work was turned over entirely to the Department of Plant Pathology of the Experiment Stations. While the emergency had passed and the interest in the onion diseases had declined, it was decided to continue the investigations long enough to finish up the lines of work that had been started.

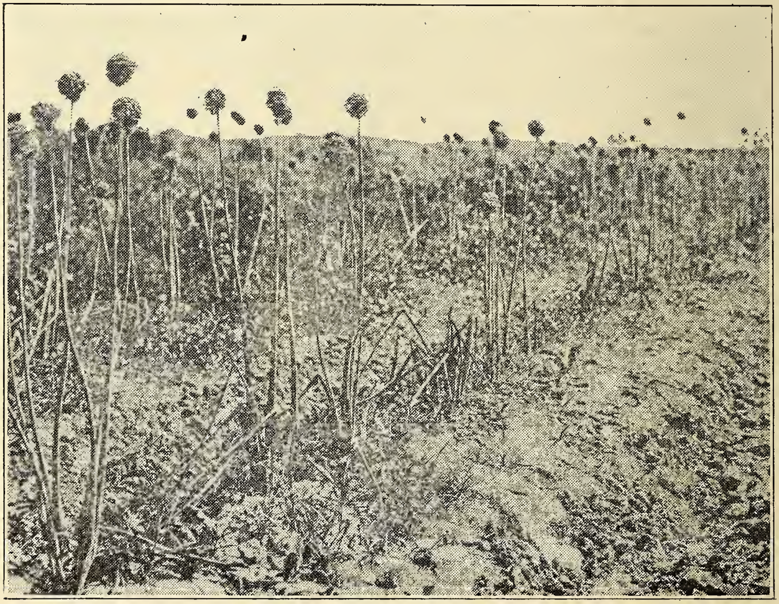

Fig. 1. A row of seed onions in Lafourche parish affected with the black stalk rot disease.

The work was undertaken primarily to see if there was any possibility of controlling the diseases by spraying. It was also the aim of those in charge to find out as much as possible regarding the cause or causes of the diseases. No attempt was made at any time to make a study of the different organisms found on onion plants. The work was confined entirely to observations on the diseases as they occurred and to some preliminary control experiments. As there is no immediate possibility of continuing the investigations, it has been thought best to publish the observations and results.

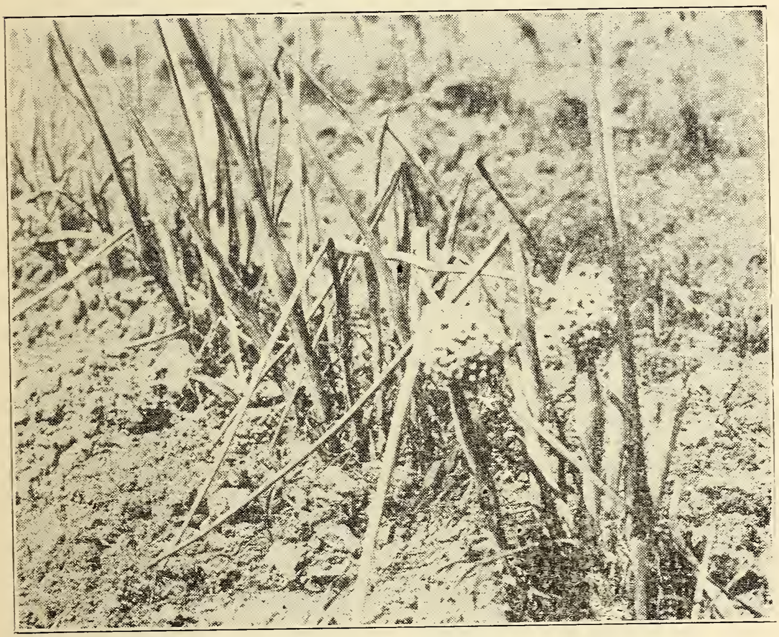

Fig. 2. Seed onions affected with the black stalk rot disease.

APPEARANCE OF AFFECTED PLANTS.

The appearance of diseased seed onions in South Louisiana is very striking. The stems of the plants become covered with a black, smutty layer of spores and mycelium of the black stalk rot fungus. Many of the stems also rot off or become so weakened that they blow over with the least wind or even fall from their own weight. In Fig. 1 is shown an infected onion field in South Louisiana and in Fig. 2, some of the infected plants. These pictures do not show an exaggerated condition but are typical of practically all of the onion patches in Lafourche, Terrebonne and adjoining parishes, and not only for one year but for every year. It is not uncommon to see half of the stalks broken off or bent to the ground. Practically all of the stalks, whether prostrate or standing, are covered with the black spore layer. Very few of the stalks which are broken or bent over produce much seed of value and the yield of the standing stalks is reduced to a considerable extent. Consequently, an estimate of fifty per cent loss is a moderate estimate of the damage caused by disease. Frequently it is considerably more than this.

WEATHER CONDITIONS.

The weather and climatic conditions seem to have a considerable bearing on the development of the onion diseases. This is shown by the difference in development of the onion troubles along Bayou Lafourche and at Baton Rouge, the two localities in which the investigations have been carried on. The lower part of Bayou Lafourche, where most of the onions are grown, is not far from the Gulf. The rainfall is heavy and humidity is high. Heavy fogs are very common during the early spring season. Furthermore, the soil is heavy and the drainage is not of the best. Baton Rouge is farther away from the Gulf and on higher ground. The fogs are not nearly as frequent and the humidity averages slightly lower.

FUNGI PRESENT ON ONION PLANTS.

There are a number of fungi present on the onion plants. While the exact importance of each has not been determined, it is evident that several of them play their part. The most common fungus present is *Macrosporium parasiticum*. Besides this, the following are frequently found: *Peronospora schleideniana, Colletotrichum circinans, Botrytis sp., Fusarium malli,* and another species of *Fusarium*. Besides these, a number of the ordinary saprophytic forms are frequently found on the old plants.

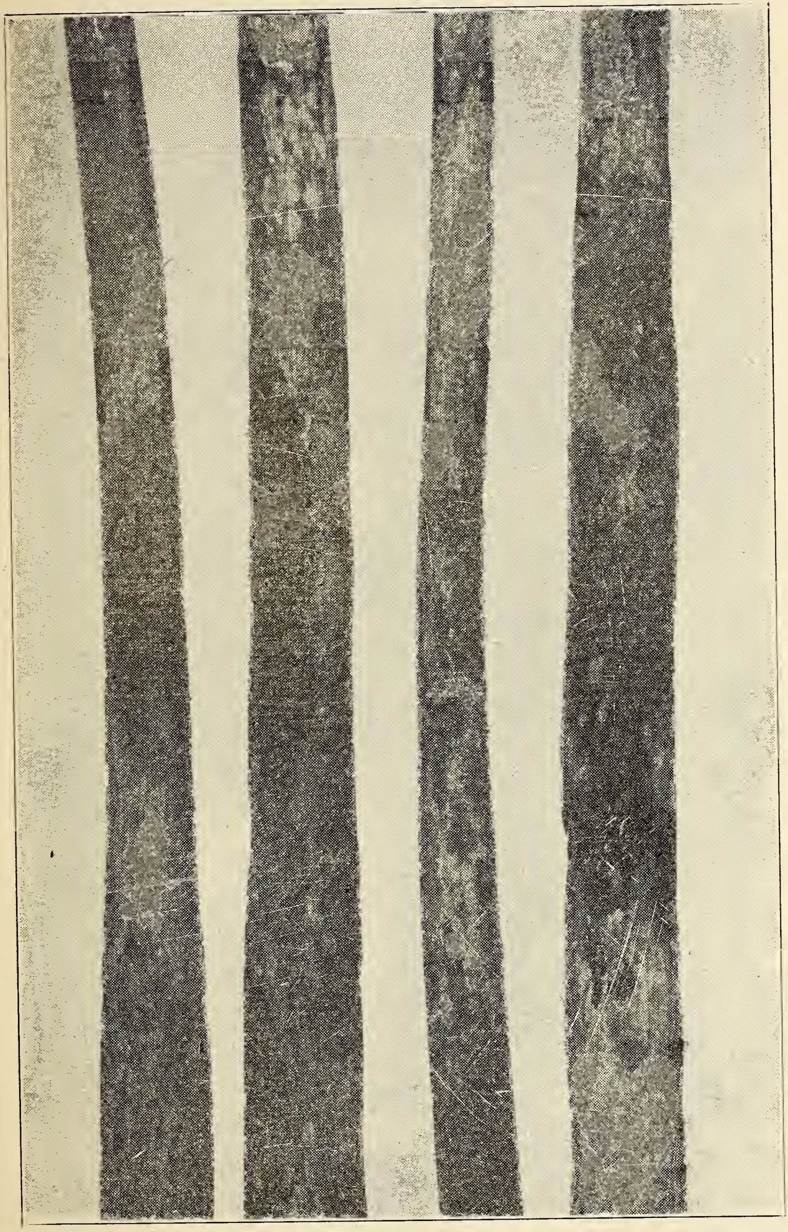

Fig. 3. Onion stalks affected with the black stalk rot disease. The black color is due to the presence of spores and mycelium of the causative fungus, *Macrosporium parasiticum.*

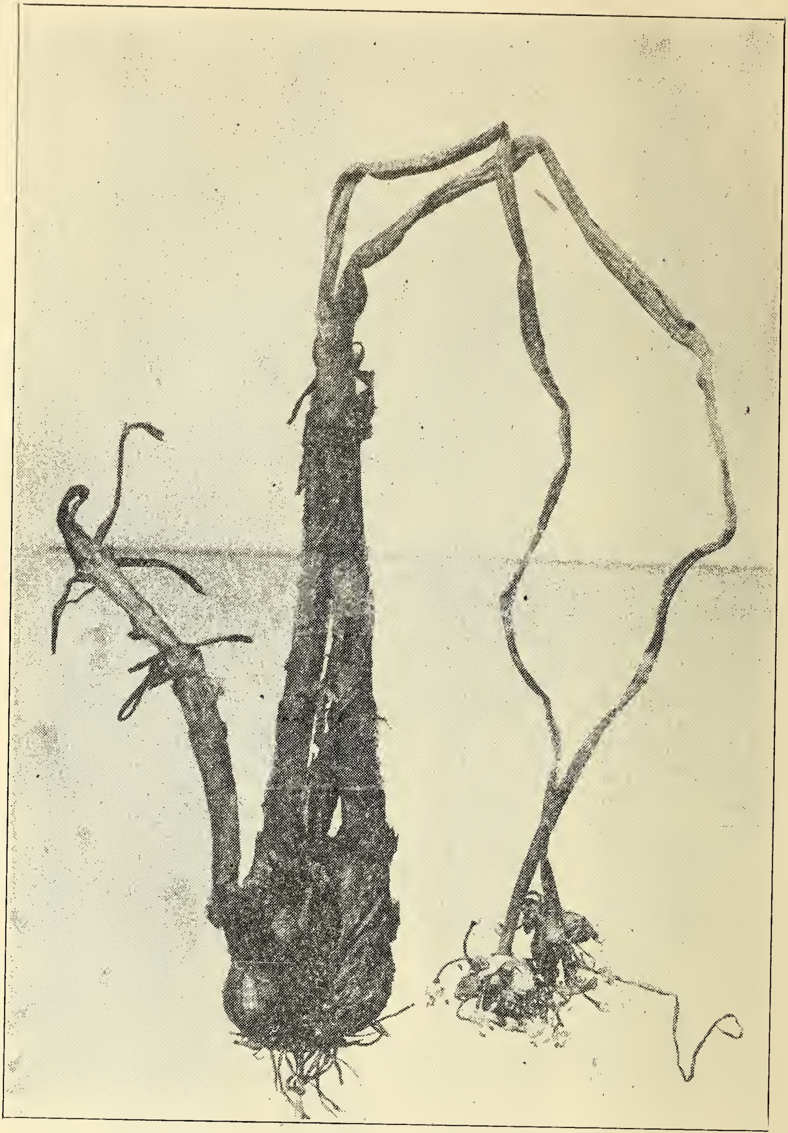

Fig. 4. An onion plant affected with the onion mildew, *Peronospora schleideniana.*

Macrosporium parasiticum is the fungus that gives the black color to the onion plants and is the cause of the black stalk rot disease (Fig. 3). All affected plants in South Louisiana are covered with this fungus and it is practically the only fungus that is found on old plants. This fungus apparently develops better in the Bayou Lafourche region than it does on the higher land at Baton Rouge. A heavy development of this fungus was also seen at Hammond during the spring of 1921, following a severe infection of onion mildew. The black stalk rot disease is practically the only disease recognized by the onion growers.

Peronospora schleideniana is the fungus which causes the onion mildew (Fig. 4.). This disease is frequently common along Bayou Lafourche upon both bulb and seed crops and there is no question that it does considerable damage. In most cases, an outbreak of onion mildew is quickly followed by the black stalk rot. Such was the case at Hammond in 1921. The onion mildew has never been seen on the high land at Baton Rouge, although during three years bulbs were brought from the infested region along Bayou Lafourche and planted.

Colletotrichum circinans (Fig. 7.) is frequently found on onion plants but not abundant enough to do much damage. This fungus was frequently seen in the plantings at Baton Rouge, being more common there than along Bayou Lafourche. This was probably due to the fact that the decreased development of the *Macrosporium* gave it a chance to develop. This fungus is also commonly found on the bulbs, producing the disease known as the onion smudge.

A Botrytis species, probably the same one that is responsible for the neck rot disease in other onion sections, has been isolated a number of times from diseased stalks and from roots. However, it has not been abundant enough to seem of any economic importance.

The pink root disease, reported by Taubenhaus to be caused by the fungus, *Fusarium malli,* is quite common in various parts of Louisiana. It occurs both on the bulb and seed crops and is sometimes severe enough to injure them. This disease has been in the State for a long time, the Experiment Station having records of it since 1909. This disease, however, plays only a minor role in the deterioration of the seed crop.

There is also an onion root rot apparently caused by a species of Fusarium (Fig. 5). This fungus causes a rotting of the roots and sometimes even causes a rot of the base of the stalk. This fungus causes a stunting of the plants and sometimes, partial sterility. Many of the flowers dry up without producing seed.

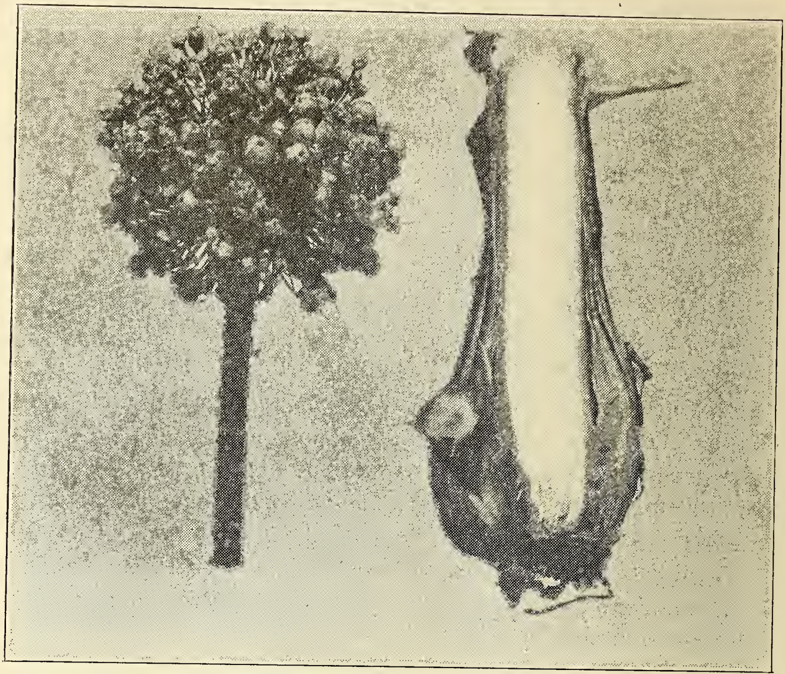

Fig. 5. Onion root rot. The roots and the base of the stalk rot and many of the flowers dry up without producing seed.

APPARENT DEVELOPMENT OF THE DISEASES.

While no inoculation or other life history experiments have been carried on with the various fungi found on onion plants, the general observations lead to several conclusions. It is evident that *Macrosporium parasiticum* is more parasitic than has been commonly believed. Under the right climatic conditions it will develop rapidly on any slightly weakened tissue and possibly will also attack the uninjured plant. There is no question that it spreads rapidly after it once gains entrance to the stalk. However, there is good evidence to show that the spread of the disease depends largely upon weather conditions. The spread is much more rapid in the Bayou Lafourche region than it is at Baton Rouge. This is well shown by the two illustrations, Figs. 1 and 8.

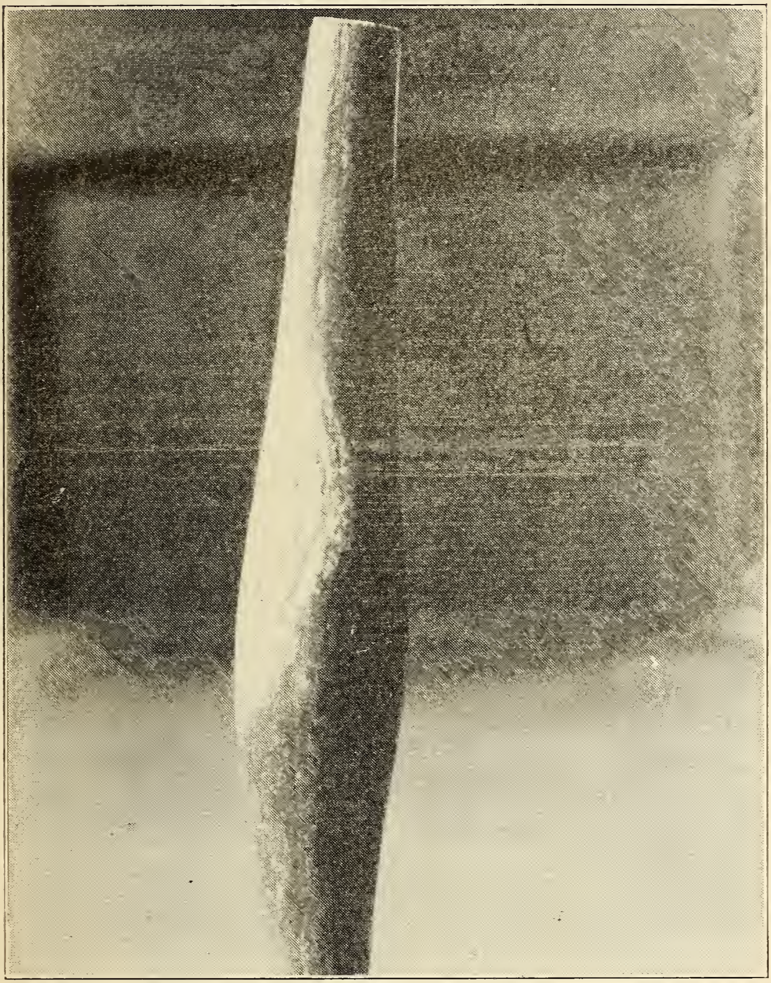

Fig. 6. An early stage of the white spot disease of seed onions.

There are two common troubles which seem to weaken the onion plants and make them more subject to the attack of the black stalk rot. These are the onion mildew and a white spot disease.

The cause of the latter has never been determined. Either or both of these commonly precede the black stalk rot disease, though this is not always the case.

The mildew is very common and frequently injures the plants very badly. Plants injured by the mildew are always overrun by the Macrosporium. In the literature on onion diseases it is generally assumed that the Macrosporium outbreaks follow attacks of the mildew. Yet under Louisiana conditions this is not always the case, as the black stalk rot is often common in fields in which no mildew can be found.

The white spot disease shows first in the form of chlorotic spots on the onion stem. These usually appear first on the enlarged portion of the stem, just above the surface of the ground. These spots (Fig. 6) are more or less circular, perfectly white in color and gradually increase in size. Cultures from these spots in the early stages have invariably given negative results, the cultures usually remaining sterile. It is possible that the cause of these spots is physiological. Soon after they show on the plants the spots easily become infected with the Macrosporium or some other fungus. In the Bayou Lafourche region this infection is nearly always the Macrosporium. At Baton Rouge, where the Macrosporium does not seem to spread so rapidly, other fungi such as *Colletotrichum circinans* and species of Fusarium are often found in these spots. In Fig. 7 are shown stems with the Colletotrichum.

CONTROL EXPERIMENTS

The first attempt in Louisiana to control the onion diseases by spraying was made by E. P. Barrios at Lockport, several years ago. He followed a tentative plan suggested to him by the Experiment Station. He sprayed the plants with Bordeaux mixture, spraying them very often, after practically every rain and heavy fog. In some weeks the plants were sprayed two or three times. This test was carried on in a year in which the diseases were very severe. He made a fair crop of onion seed and was one of the few growers that did. As he obtained a good price for the seed he was very well satisfied with the test.

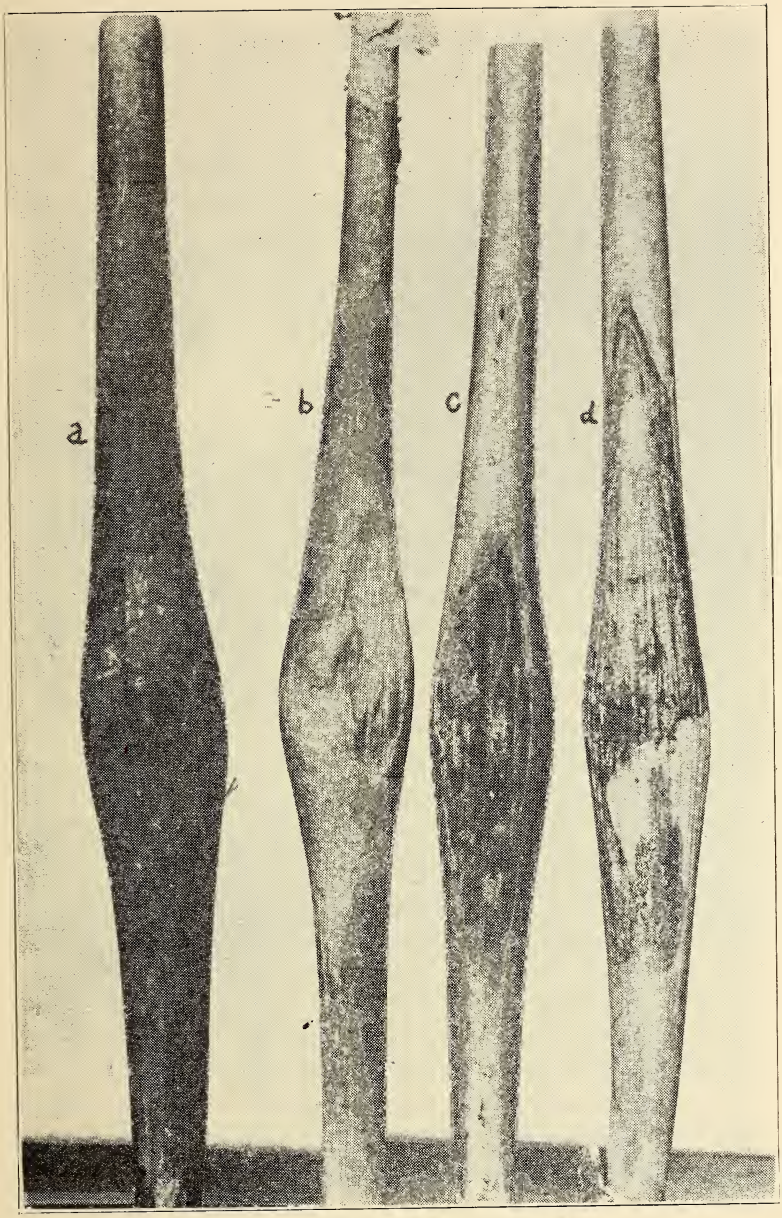

Fig. 7. Stages of the white spot disease.
(a) A healthy stalk; (b) A stalk with the spot becoming sunken, somewhat older than the spot shown in Fig. 6; (c) and (d) Stalks with old spots that have been overrun with *Colletotrichum circinans*.

In 1919, spraying tests were carried on cooperatively at Baton Rouge and Thibodaux by the Experiment Station and the United States Bureau of Entomology. Thibodaux is on Bayou Lafourche and is in the region where the growers have experienced the most difficulty in growing seed. The experiment at Baton Rouge was conducted in the Experiment Station garden, where it was possible to watch the plants carefully.

SPRAYING TESTS AT BATON ROUGE

For the spraying test at Baton Rouge, six rows of onions, 110 feet long, were set in the field in October 1918. The bulbs had been shipped in from Lafourche Parish, in order to introduce as far as possible, the diseases of that region. The onions were set in the field earlier than is the practice along Bayou Lafourche, but this seemed advisable on account of the slightly different weather conditions. The plants were beginning to send up seed stalks on February 13. During the winter and early spring beginning on January 29 and ending on May 1 these rows were sprayed with fungicides and insecticides.

The spray materials used were Bordeaux Mixture, distillate and nicotine sulphate (Blackleaf 40). These were used in various combinations. The Bordeaux Mixture was made at the 4-4-50 strength. The distillate, which was added as a sticker, was used at the rate of one part to the hundred. The Blackleaf 40, which was added to check thrips or other insects, was used at the rate of one part to the thousand. The different rows were sprayed as follows:

Row 1. Sprayed eleven times at weekly intervals with a combination of Bordeaux Mixture, distillate and Blackleaf 40, listed as Bordeaux-distillate-nicotine in the table below, first spraying on January 29 and last spraying on May 1.

Row 2. Left as a check, not sprayed.

Row 3. Sprayed nine times at weekly intervals with the Bordeaux-distillate-nicotine solution, first spraying on February 13 and last spraying on May 1.

Row 4. Sprayed like No. 3, except Bordeaux Mixture alone was used.

Row 5. Sprayed like No. 3 except a combination of Bordeaux Mixture and distillate, listed as Bordeaux-distillate in the table, was used.

Row 6. Sprayed like No. 3, except a combination of distillate and Blackleaf 40, listed as distillate-nicotine in the table, was used.

The solutions containing the distillate covered the plants better than the Bordeaux Mixture alone and were not as easily washed off by the rains. The plants were well covered with the spray mixtures at all times.

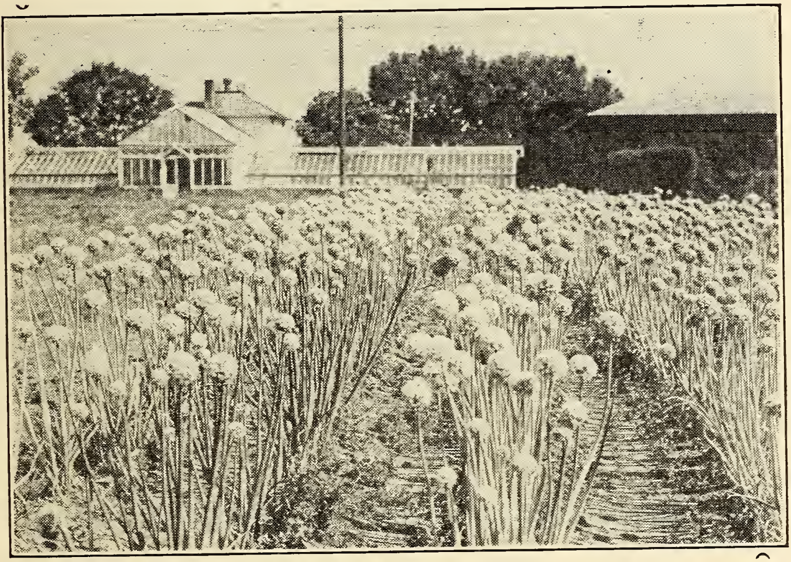

Fig. 8. The onion field used in the spraying test at Baton Rouge 1919. All plants remained remarkably free of disease.

All the plants remained remarkably healthy throughout the season (Fig. 8). There was a small amount of the Macrosporium, a little Botrytis and Fusarium injury and some Colletotrichum. Many of the plants had the white spots on them but these did not become seriously overrun with any of the fungi common in the Bayou Lafourche region. The seed were gathered as they ripened, during the latter part of May and the first of June. The results of the test are given below:

Table 1. Results of Onion Spraying Experiment, Baton Rouge, La., 1919.

Row No.	Treatment	Times Sprayed	Yield in Pounds of Seed Per Row
1	Bordeaux-distillate-nicotine.........	11	5.8
2	Check...........................		4.6
3	Bordeaux-distillate-nicotine.........	9	6.7
4	Bordeaux.........................	9	4.6
5	Bordeaux-distillate................	9	5.9
6	Distillate-nicotine................	9	4.8

The table shows an apparent gain in those rows that had both the Bordeaux Mixture and the distillate. But the test was not conclusive and it is doubtful if the spraying as it was carried on was a paying proposition.

SPRAYING TEST AT THIBODAUX

The spraying test at Thibodaux (Fig. 9) was on a row of onions about 440 feet long. This row was stepped off into five sections of practically equal length. The first of these sections was left as a check, while the others were sprayed with the same solutions as were used at Baton Rouge. The second section was sprayed with the Bordeaux-distillate-nicotine solution; the third with the Bordeaux-distillate solution; the fourth with the Bordeaux Mixture alone; and the fifth with the distillate-nicotine solution. The plants were sprayed on March 18, March 25, April 1, April 8, April 15, April 22, April 29, May 6, May 13 and May 20. The last spraying was about two weeks previous to the maturity of the plants.

On May 20, counts were made of the total number of stalks in each section and also of the number that had fallen over from disease, listed as *down stalks* in the table below.

In Table 2, are given the results of the spraying test. The table includes the total number of stalks, the number and percentage down on May 20, the actual yield of the different plots and the yields estimated to the same number of stalks that were present in the check plot. When the stalks were counted, it was found that the check plot had a better stand than the rest and it seemed preferable to estimate the yield to the same number of stalks.

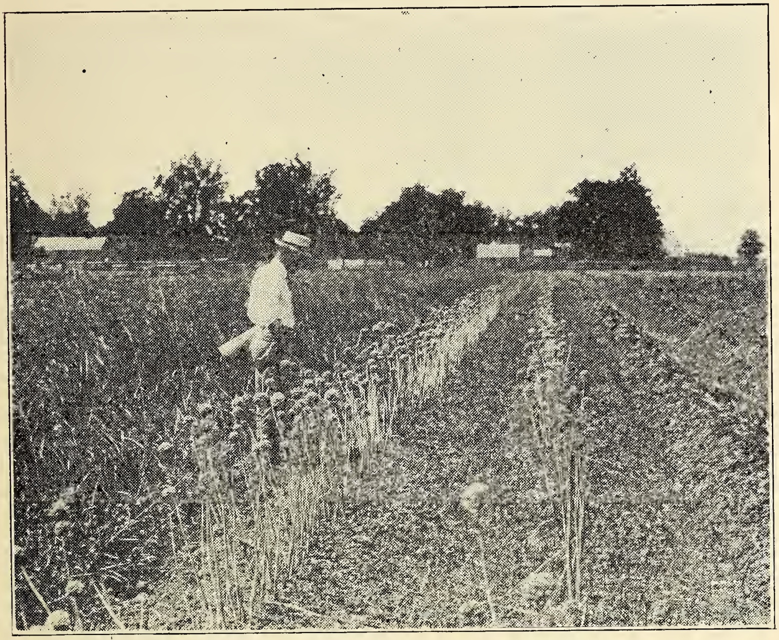

Fig. 9. The onion row used in the spraying test at Thibodaux, in 1919. In the foreground is shown one of the sprayed sections.

Table 2. Result of Onion Spraying Experiment, Thibodaux, La., 1919.

Plot	Treatment	No. of Stalks	No. of Down Stalks	Percent of Stalks Standing	Actual Yield in Pounds	Estimated Yield. (See Text)
1	Check..................	877	256	70.8	1.88	1.88
2	Bordeaux-distillate-nicotine.............	806	131	83.7	1.63	1.77
3	Bordeaux-distillate.....	796	151	81.0	2.13	2.34
4	Bordeaux..............	707	99	86.0	1.75	2.17
5	Distillate-nicotine......	653	83	87.3	1.38	1.85

An examination of the table shows that all of the sprayed plots had a higher percentage of standing stalks but no definite conclusions can be drawn from the yields. It seems fairly certain that any extra yield that might have been obtained did not pay for the expense of spraying the plants ten times. It also seems probable that onion plants will have to be sprayed oftener than once a week in the Bayou Lafourche region, in order to protect them from the black stalk rot and other diseases.

GROWING SEED AT BATON ROUGE

Having had such good success with the onions that were grown at Baton Rouge in 1919, it was decided to continue the seed plots for at least two more years. The winter of 1918-1919 had been comparatively mild and there was a question whether the seed could be grown satisfactorily in a cold or even a normal winter. Unfortunately for the tests, the two following winters were also comparatively mild and there has been no opportunity to grow seed during one of the colder winters. However, the three winters of 1918-19, 1919-20 and 1920-21 were suitable for growing onion seed and good crops were obtained each season.

In 1919, the plot in seed onions, which was the same one as was used in the spraying experiments, covered one-twentieth of an acre; in 1920, it was about the same size; and in 1921, it was about one-thirteenth of an acre.

In 1919, the check row produced at the rate of 520 lbs. of seed to the acre, while the best sprayed plot produced 755 lbs. to the acre.

The 1920 crop was also planted with bulbs shipped in from Lafourche parish. There was very little disease on the plants throughout the season. The plot produced at the rate of 475 lbs. of seed to the acre.

In 1921, three different lots of bulbs were used for planting and these were planted on different dates. One lot had been grown at Baton Rouge from seed that had been produced in 1919 at Baton Rouge. These bulbs were sound but were comparatively small as they had been grown in a dry season. A second lot of the bulbs came from Lafourche parish. These were not very good as they had evidently been graded out at the time the crop was sold in the spring. However, these were larger than the ones which had been grown at Baton Rouge. The third lot of seed bulbs came from Pointe Coupee parish. These were large and from outward appearances, the best of the three lots. The onions were planted on different dates to see if early or late planting would have any effect on the seed crop. There was but little of the Macrosporium on any of the plants but the rows planted from bulbs raised at Baton Rouge seemed to have more of the Fusarium root rot than the other rows. The yield from these different plots is shown in Table 3.

Table 3. Yield of Onion Seed at Baton Rouge in 1921.

Origin of Bulbs	Date Set in Field	Yield in Pounds per Acre
Baton Rouge	October 15	330
Baton Rouge	November 8	350
Lafourche	October 15	445
Lafourche	November 8	403
Pointe Coupee	November 17	635

The average yield of the whole acreage in 1921 was at the rate of 416 lbs. of seed to the acre.

In the spraying test at Thibodaux in 1919, the plot yielded at the rate of 283 lbs. to the acre, figuring on the same width of rows as was used at Baton Rouge. The onions in the test at Thibodaux compared well with any of the other fields in Lafourche parish, and it is doubtful if the average for that parish was as high as 250 lbs. to the acre.

From the tests, it is seen that the onions at Baton Rouge produced nearly twice as much seed as did those in Lafourche parish. This was unquestionably due to the fact that the plants at Baton Rouge were not seriously attacked by the diseases which are so troublesome in the Lafourche region, due, as it would seem, to the somewhat less rainfall and the lower humidity.

The Macrosporium was present at Baton Rouge but did not seem to spread very rapidly. None of the onion mildew was ever seen at Baton Rouge, although the bulbs from which the seed was raised, were received from Lafourche parish where the mildew is present. It is possible that with an outbreak of mildew, no better results would be obtained at Baton Rouge than in Lafourche parish. Whether the mildew will develop on the high land at Baton Rouge as well as it does in the alluvial sections, is still a question.

These tests would seem to show that seedsmen would be more successful in producing seed for the market by having them grown outside the lower coast region. It would seem that the seed could be produced cheaper and that the crop would be as certain.

SUMMARY

1. In certain parts of Louisiana, especially along the lower coast in Lafourche and Terrebonne parishes, the onion seed crop is seriously reduced by diseases. These troubles usually reduce the crop about fifty per cent.

2. The principal organism present on the plants is *Macrosporium parasiticum*, but a number of other organisms are also present.

3. The Macrosporium follows the attack of the mildew and a white spot disease which is possibly physiological in nature. It is believed also that it attacks the uninjured plants when circumstances are right.

4. The disease causes the stalks to turn black and rot.

5. Spraying at weekly intervals has not given satisfactory results. To be effective, it is believed that spraying would have to be oftener.

6. Seed can be raised to better advantage away from the lower coast region, due to the greater freedom from disease. Tests at Baton Rouge have shown yields nearly twice as large as in Lafourche parish.

TECHNICAL

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LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE

AGRICULTURAL EXPERIMENT STATIONS

W. H. DALRYMPLE, Dean and Director

BATON ROUGE, LOUISIANA

PRELIMINARY NOTES ON PARASITES FOUND IN RUMINANTS AT MUNICIPAL ABATTOIR, BATON ROUGE, LOUISIANA

BY
G. DIKMANS, D. V. M.
Parasitologist and Assistant Veterinarian

Preliminary Notes on Parasites Found in Ruminants at the Municipal Abattoir, Baton Rouge, Louisiana

By

G. Dikmans, D. V. M.

Some nematodes found in the abomasum of cattle at the Municipal Abattoir in Baton Rouge, La., were examined by the writer, at the Zoological Laboratory of the Bureau of Animal Industry, Washington, D. C. Among these specimens were some stomach worms which did not correspond to the description of *Hæmonchus contortus* and which are evidently identical with the stomach worm described from cattle in Brazil, by Travassos, as *Hæmonchus similis,* (Brazil Medico, May 15, 1914).

A comparison of the Louisiana material with specimens of *Hæmonchus similis* in the collection of the Zoological Division, (B. A. I. collection, No. 1702 B) confirms the identification.

Dr. Travassos' description of the *Hæmonchus similis* is as follows:

''Length—

Male, 8.5mm; female, 12-14mm.

Thickness—

Male, 0.224-0.255mm; female, 0.284mm.

''Body with fine transverse and longitudinal striations; oesophagus enlarged near the posterior end, about 1.072-1.200mm in length; excretory pore situated more or less at the level of the nerve ring, about 0.234mm from the anterior extremity; cervical papillae about 0.319mm to 0.340mm from the anterior end. The vulva of the female is located about 2.5mm to 3mm from the caudal extremity on the tip of a conical projection about 0.300mm in length; eggs ellipsoidal, in the first stages of segmentation in the uterus, about 0.070-0.078mm long and 0.035-0.038mm wide. There are two small papillae near the caudal extremity, about 0.063-0.071mm from the end; the anus is 0.213-0.248mm from the posterior end.

“Male with a large trilobed bursa, median lobe asymetrically placed; postero-lateral rays thickened towards the extremity; spicules long, 0.319-0.333mm ending in blunt, button-like knobs, with recurving points like the barb on a harpoon; the point on the left spicule about 0.049-0.056mm from the end and that on the right about 0.063-0.071mm from the distal extremity.

Gubernaculum indistinct, about 0.156mm long;

Habitat, 4th Stomach of Bos Taurus.

This species is similar to *H. contortus,* (Rudolphi), from which it differs in the following characters:

Similis.	Contortus.
Male 8.5m.	Male, 19-21mm
Female, 12-14mm.	Female, 23-24mm.
Vulva on the apex of a conical projection.	Vulva at the base of a triangular attenuated expansion.
Spicules.	
0.319-0.333mm.	0.400-0.430mm.
Hooks, 0.049-0.056mm and 0.063-0.071mm. from the distal extremity.	Hooks, 0.014-0.017 and 0.028-0.032mm. from the distal extremity.
Gubernaculum	
Not easily visible, about 0.156mm long.	Plainly visible, about 0.276 mm.
Postero-lateral rays.	
Enlarged near their extremity.	Slender in their entire length.

While the females in our collection compare very favorably with those of *H. similis* in the collection at Washington, as may be seen from the accompanying figures (Plate 1.) the male shows some differences—notably the decided and clear-cut appearance of the gubernaculum, (Plate 2). The dimensions of these spicules are as follows:

Length: 0.323-0.326mm, ending in button-like knobs;

Hooks: 0.0532-0.606 and 0.0644-0.0728mm from the tips of the spicules.

Gubernaculum plainly visible, 0.128.8-0.1428mm in length, elliptical in shape 0.025mm at its widest point. When seen in profile it appears somewhat crescentic. Other males do not show the gubernaculum as plainly as is shown in the accompanying illustration.

In a recent paper by Travassos on the Trichostrongylidae, published in the Memorias do Instituto do Oswaldo Cruz, vol. 12, 1921, he has extended the description of this species and figured it. His figures agree with our material. He reports this species from Brazil and Europe. Our record is therefore new for North America and we are publishing figures of this species for the benefit of the American veterinarians and zoologists who do not have access to Travassos' paper.

While studying various specimens of *H. contortus,* considerable variation was observed in the linguiform process covering the vulva of the female. This variation has been noted by Dr. Frank Veglia in his "The Anatomy and Life History of the *Hæmonchus contortus,* (Rud.) published in the 3d. and 4th Rep. Director of Vet. Research, Union of South Africa, Pretoria, pp. 349-471, Nov. 1915. Dr. Veglia's report is as follows:

"*Apparent Anomalies of the Vulva Linguiform Process:*

In general I found that the anatomy of *Hæmonchus contortus* was fairly constant in regard to appearance and size of the different organs, but at the time of marked reproductive activity I met with a very large number of rather old female worms, showing peculiar differences in the linguiform process. In some sheep about twenty-five per cent female worms showed the following peculiarities: The linguiform process was unusually short, measuring 0.250mm in length and about 0.170mm at the base. It was conical in shape, adhering to the body and slanting towards the tip, with contents granular in appearance. In other specimens it was represented by a pimple-like body, protruding for a distance of about 0.025mm sometimes placed anteriorly and at other times situated laterally to the vulva. In some specimens the linguiform process was quite absent and the opening of the vulva was only indicated by a rudiment of the above-mentioned vulval lips. There were no other remarkable changes in the remainder of the genital organs except that the vagina was sometimes situated in a direction perpendicular to the ventral side of the body, instead of occupying the oblique position already described. The laying of eggs was performed quite normally. I might also add that the anomalies mentioned were found in different seasons of the year."

All the anomalies mentioned by Dr. Veglia were observed in our specimens. In a number of specimens the short, conical process referred to by Dr. Veglia was situated laterad to the vulval opening, at other times apparently dorsad. These variations are shown in the figures published here (Plate 3).

A third interesting subject investigated during the work at Washington was the unusual variation in size of some specimens of what appear to be *Bunostomum phlebotomum* in our collection. The females in this material are 25mm long and the males 18mm long, which is from 5 to 6mm longer than the maximum length reported by Ransom, in B. A. I. Bull. 127, for the same species. These specimens were found in the 4th stomach of calves.

Vial No. 13 of our collection contains specimens collected from the abomasa of four cows, under date of April 7, 1921. In this vial are eight males and eighteen females of *Arduenna strongylina* and three females of *Physocephalus sexalatus*. These have been frequently reported from swine and are reported from this host in the United States by Foster, in B. A. I. Bull. 158. They are found to be of frequent occurrence in swine slaughtered at the Municipal Abattoir at Baton Rouge. These worms have never been reported as parasites of cattle, but Ransom and Raffensperger have reported the development of *Arduenna strongylina* in the guinea pig after feeding larvae of this species from coprophagous beetles. Since cattle and swine are ungulates and more closely related than swine and rodents, the occasional and accidental occurrence of swine nematodes in cattle appears to be within the bounds of possibility. The collection of the writer's material was made under circumstances which appear to preclude the possibility of confusion of any sort. No swine were being killed at the time these worms were collected and when collected it was noted that these worms differed from the other worms found in the stomachs of the cattle examined.

I wish to express to Drs. Ransom and Hall and to Mr. Chapin, my sincere appreciation for their invaluable aid generously rendered during the work; to Dr. Hall for his assistance in the preparation of this paper; to Dr. Martin, manager and veterinary inspector at the abattoir, for his unfailing assistance in the collection of the material; and to Mr. Haines, Artist for the Bureau, for the drawings reproduced here.

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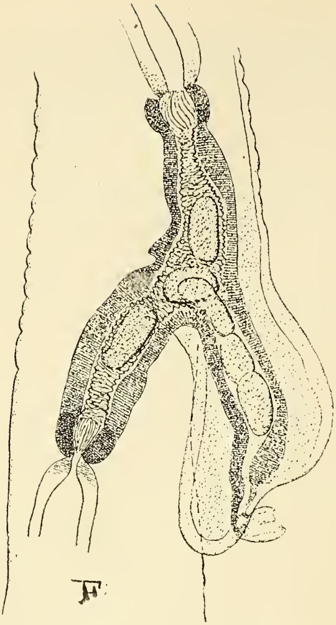

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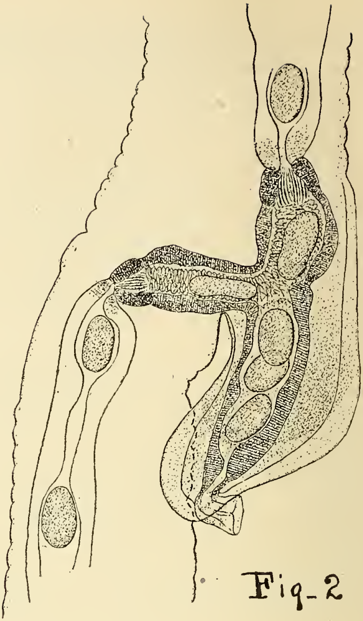
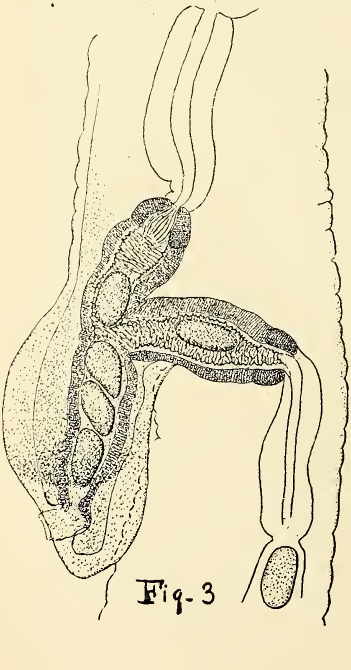


Fig-2



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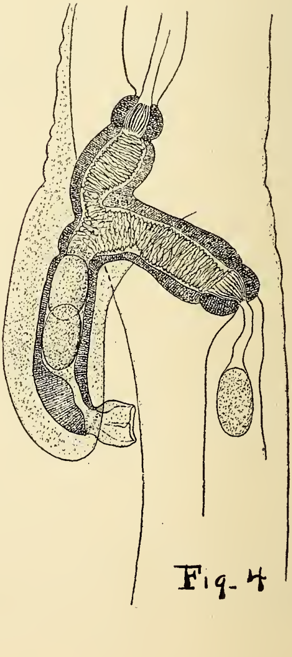

Fig-4

PLATE NO. 1

Fig. 1. Hæmonchus similis (female). Drawn from Travassos' original in the collection of the Zoological Division B. A. I., Washington, D. C.

Fig. 2, 3 and 4. Hæmonchus similis (female). Original material collected at Baton Rouge Municipal Abattoir, Baton Rouge, La.

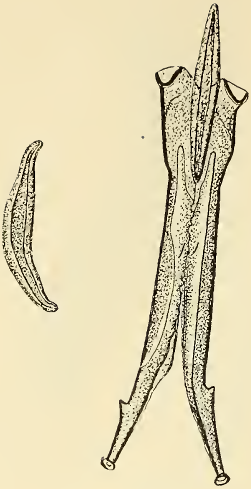

Fig. 1

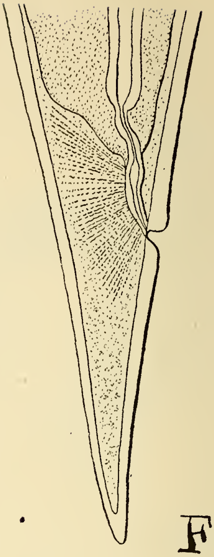

Fig. 2

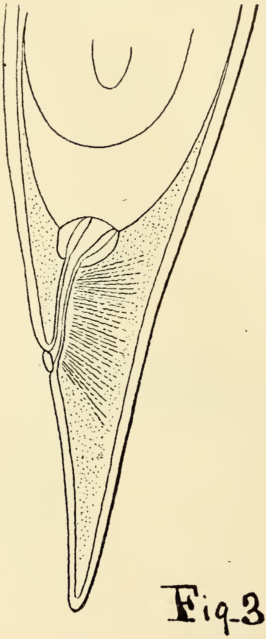

Fig. 3

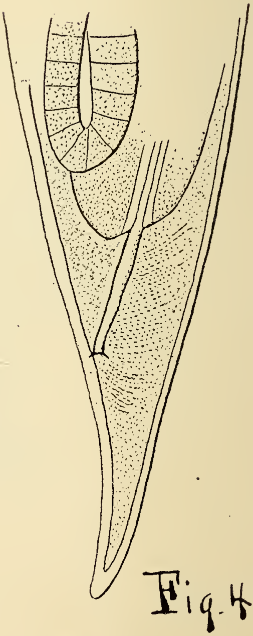

Fig. 4

PLATE NO. 2

Fig. 1. Spicules of Hæmonchus similis. A lateral view of Gubernaculum.

Fig. 2, 3 and 4. Tail of Hæmonchus similis.

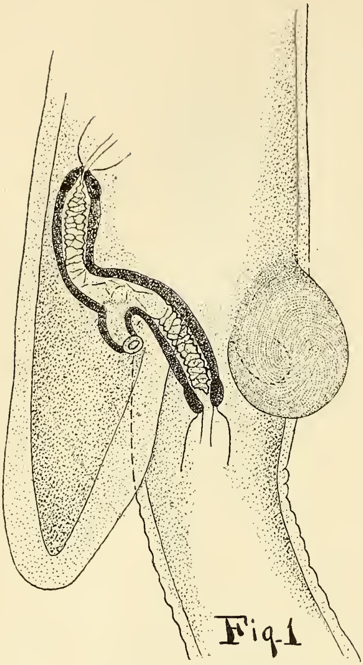

Fig-1

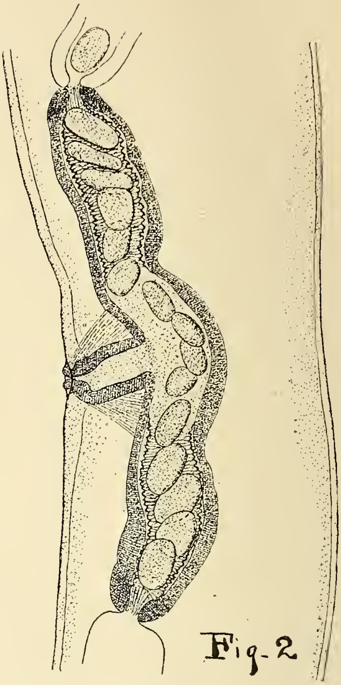

Fig-2

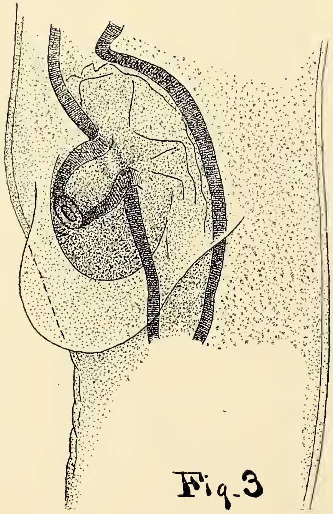

Fig-3

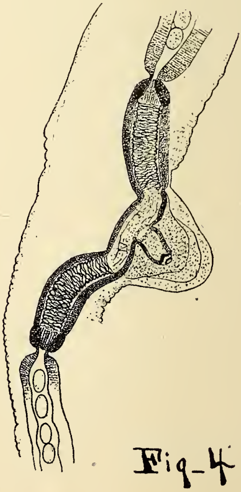

Fig-4

PLATE NO. 3

ANOMALIES OF LINGUIFORM PROCESS IN H. CONTORTUS.

Fig. 1. Female showing vesicular excresence.

Fig. 2. Female showing entire absence of linguiform process.

Fig. 3. Modified linguiform process situated laterad to vulval opening.

Fig. 4. Modified linguiform process.

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AGRICULTURAL EXPERIMENT STATIONS

W. R. DODSON, DEAN AND DIRECTOR

BATON ROUGE, LOUISIANA

TESTS OF THE WILT RESISTANCE OF DIFFERENT TOMATO VARIETIES

BY
C. W. EDGERTON,
PLANT PATHOLOGIST
AND
C. C. MORELAND,
ASS'T PLANT PATHOLOGIST

TESTS OF THE WILT RESISTANCE OF DIFFERENT TOMATO VARIETIES.

C. W. EDGERTON AND C. C. MORELAND.

Investigations of the past few years on the tomato wilt disease*, caused by the fungus, *Fusarium lycopersici,* have demonstrated that different tomato varieties are not equally susceptible to the disease, and also that it is possible to breed up by selection and hybridization, varieties which are more or less resistant. As a result of this, a number of different varieties, claimed to be more or less resistant or tolerant, have been developed by various experiment stations of the southern and middle states, by the United States Department of Agriculture and by various seedsmen and growers. From the investigations, it seems evident that this disease, which is probably the most serious of the tomato diseases in the southern states, will be largely controlled in the not distant future, by the use of such selected, resistant varieties.

In order to obtain some information on the relative resistance and value of the different commercial varieties and the various wilt-resistant selections which have been developed at various places, variety tests have been conducted on the Experiment Station farm at Baton Rouge, during a period of three years. As a result of these tests, a fairly accurate idea of what can be expected of the different varieties on wilt-infested land in Louisiana has been obtained. Similar information from other regions would be extremely valuable. These tests have also shown the relative value of the varieties which have been developed at the Louisiana Experiment Station, and this information was necessary before these varieties could be recommended for general planting.

NATURE OF THE VARIETY TESTS.

The comparative resistance of the different tomato varieties to wilt was obtained by two methods—by testing small plants in pots in the greenhouse and by field tests.

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*For a description of the tomato wilt disease and the resistant varieties which have been developed at the Experiment Station, consult Louisiana Bulletin No. 174.

The greenhouse tests were run for two seasons, 1919 and 1920. The same varieties and the same lots of seed were used in these tests as were used in the field trials. For the greenhouse tests, soil was placed in pots, sterilized in the autoclave and then heavily contaminated with pure cultures of the tomato wilt fungus. Immediately after the fungus was mixed in the soil, the pots were planted with seed of the different tomato varieties. Three pots were used with each variety and from seventy-five to a hundred plants were grown in each pot. Tomato plants grown in this way take the disease very readily. Sometimes the wilt shows in the plants within a week after they are above the ground. In the tests, the percentage of wilt was obtained at weekly intervals or less during a period of eight or nine weeks. The greenhouse tests were run in order to determine if young plants were more susceptible than older ones and also to see if greenhouse results would agree with those obtained in the field.

The field tests were run for three seasons, 1919, 1920, and 1921. The same plot of ground was used each season. This plot was known to be heavily infested with the wilt as tomatoes had been grown in it during the preceding nine years. The tests of the different years were conducted in practically the same manner. The young plants were grown in the greenhouse in soil free of the disease and were set in the field during the early part of April, the plants being approximately two months old at the time of transplanting. The general method of setting the field was the same each season. Beginning at one end of the plot, a row of each variety was set; then this order of planting was duplicated over and over until the whole plot was set. This gave an equal number of rows of each variety and also had them separated in the field. This method of planting eliminated to a considerable extent the effect of variations in the soil. The plot was somewhat more fertile at one end than at the other, but the method of planting placed some of the rows of each variety under the different conditions of fertility. The plot of ground was 130 feet wide and the plants were set two feet apart in the rows, thus making sixty-five plants to the row. The number of rows of each variety varied from year to year, depending upon the number of varieties used. The plants were staked and tied and were pruned once or twice during the season. Various other diseases besides the wilt were present and each of these had its effect upon the yields obtained, yet these diseases were well distributed over the different varieties. The two most important diseases present other than the wilt, were the early blight (*Macrosporium solani*) and the mosaic. The early blight cut off the crop at the end of each season.

VARIETIES TESTED.

The varieties tested each season included selections which had been developed at the Louisiana Experiment Station, various wilt resistant varieties obtained from the United States Department of Agriculture and other experiment stations and a number of commercial varieties. The commercial varieties, Stone, Globe and Earliana, were included in each test. The Stone was known to be extremely susceptible to the wilt and the Globe fairly resistant, while the Earliana is an early variety which usually makes a part of a crop before the wilt has time to kill the plants. The Louisiana wilt-resistant selections have been described in a previous publication, (Louisiana Bulletin No. 174). They are at present being called Louisiana Red and Louisiana Pink.

TESTS IN 1919.

The results of the 1919 variety tests were included in a previous bulletin (Louisiana Bulletin No. 174), but for purposes of comparison, the general results are repeated here.

There were thirteen varieties included in the tests, the two Louisiana varieties, four resistant varieties from F. J. Pritchard, of the United States Department of Agriculture, and a number of commercial varieties purchased from a seed store in Columbus, Ohio. Both the greenhouse and field tests were included in the work for 1919.

The greenhouse test was started in September, 1919, at a time when the temperature conditions were very favorable for the development of the wilt. The test was run in the manner described in a previous paragraph, continuing over a period of fifty-nine days from the time of planting. The results of this test are shown in Figure 1, the curves showing the percentage of wilt in each variety at different periods after planting. The

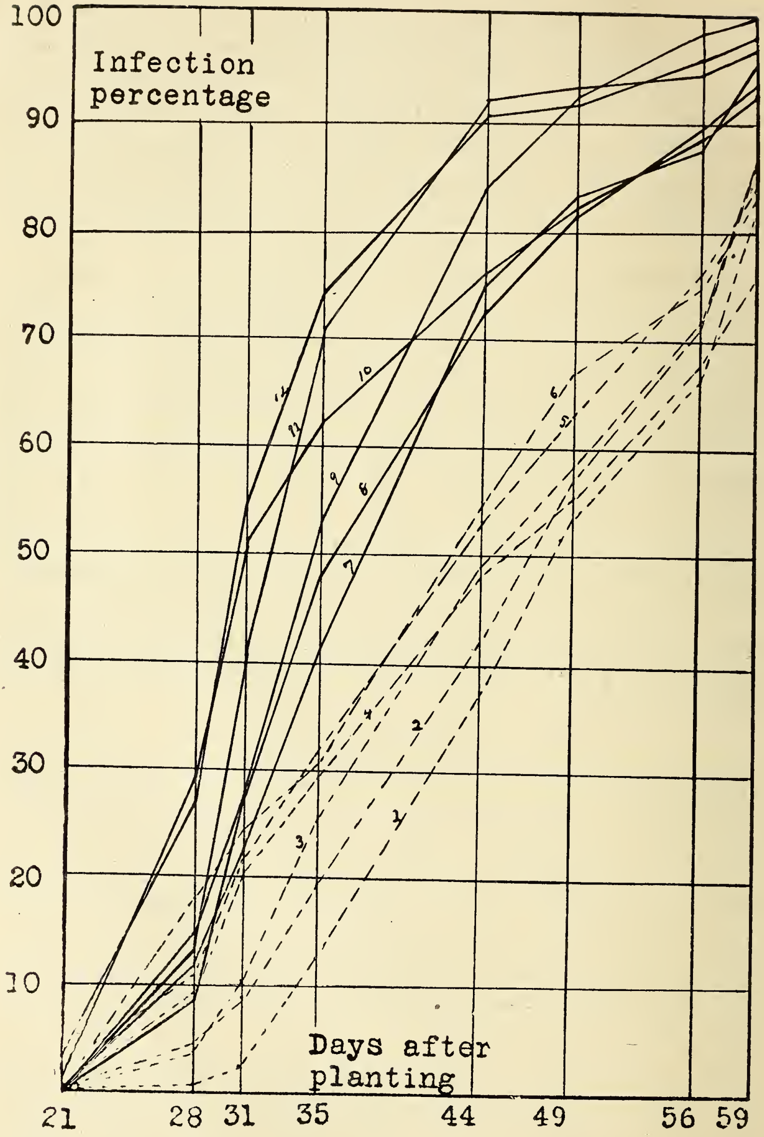

Fig. 1. Curves showing percentage of wilt in different varieties in re-inoculated sterilized soil in greenhouse, 21 to 59 days after planting test started in September, 1919. Curves 1 to 6 are selected resistant varieties; curves 7 to 12 are commercial varieties. See Fig. 2 for names of varieties.

varieties which had been selected for wilt resistance are represented by broken lines, while the commercial varieties are represented by continuous lines. As is readily seen, there was considerably more wilt in the commercial varieties than in the selected ones.

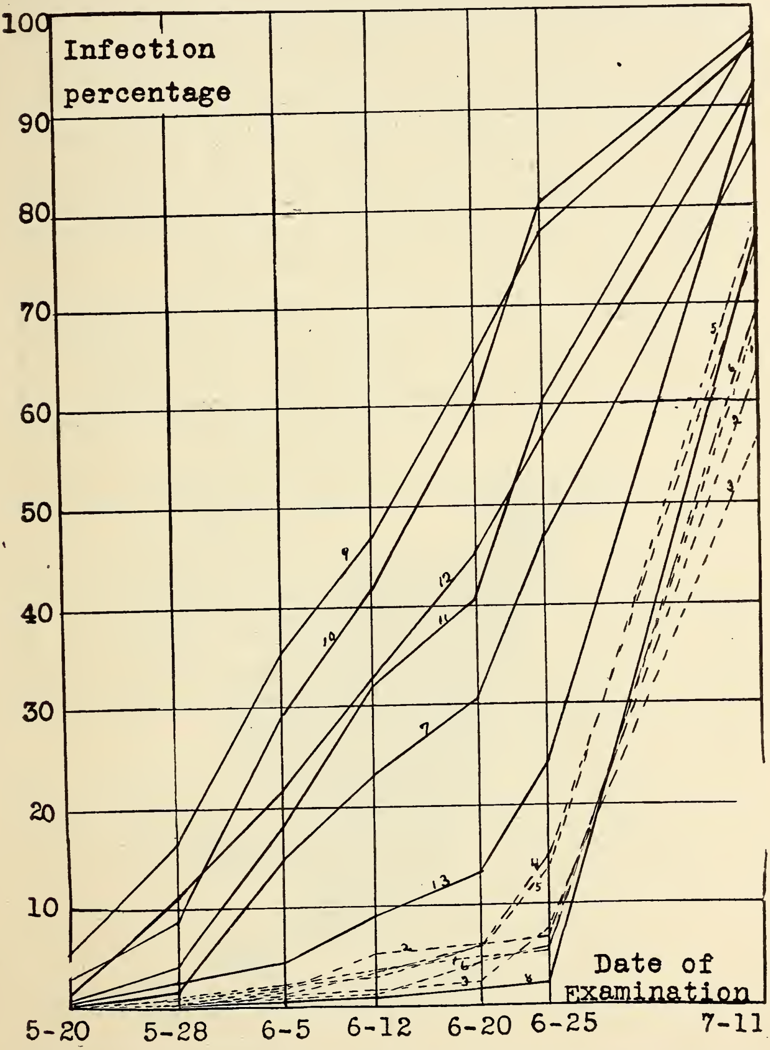

Fig. 2. Curves showing percentage of wilt in different varieties in the field at different dates in 1919. Last percentage was obtained by cutting the plants. Curves 1 to 6 are selected resistant varieties; curves 7 to 13 are commercial varieties. (1) Louisiana Pink; (2) Louisiana Red; (3) Marvel; (4) Columbia; (5) Arlington; (6) Norton; (7) Earliana; (8) Globe; (9) Stone; (10) Bonny Best; (11) June Pink; (12) Chalk's Early Jewel; (13) Manyfold.

In the field tests, five rows were planted with each variety. Data were obtained upon the percentage of wilt at all times during the season and also upon the yield of fruit.

The percentage of wilt was obtained at frequent intervals throughout the season. The results are presented in Figure 2. The curves show the percentage of wilt in the several varieties on different dates. On the last date, July 11, which was at the close of the picking season, the plants were cut and the stems examined for discolored fibrovascular bundles, and consequently the actual wilt percentage is shown. On the other dates, the percentage was obtained by counting the plants showing apparent wilt symptoms. In the figure, the curves for the selected resistant varieties are again shown by broken lines and those of the commercial varieties by continuous lines.

All the resistant varieties showed a slow development of the wilt during the early part of the season, while the percentage of wilt in the susceptible varieties increased very rapidly. Two of the commercial varieties, the Globe and the Manyfold, showed less wilt than the others. The Globe showed as much resistance as did the selected varieties, while the Manyfold was more or less intermediate between the resistant and the susceptible varieties.

On account of an early blight epidemic and unfavorable weather conditions, the picking season in 1919 was short, covering a period of only five weeks, beginning on June 7 and ending on July 12. The short season was favorable for the development of the early varieties but the yield of the late varieties was considerably decreased.

The final results for the 1919 tests are given in Table 1 and Figure 3. The table shows the yield of each variety and the wilt percentages at the middle and end of the picking season. The yields are figured in tons on an acre basis.

TABLE 1

Comparison of Different Varieties in the Field in 1919

VARIETY	Apparent Wilt Percent, June 25.	Actual Wilt Percent by Cutting, July 11.	Yield, Tons per Acre
June Pink	60.1	96.6	5.9
Earliana	47.6	87.6	5.7
Louisiana Pink	6.3	69.3	5.4
Louisiana Red	6.2	62.2	5.2
Arlington	13.2	77.7	5.1
Marvel	6.6	55.7	4.6
Norton	5.0	70.0	4.5
Columbia	15.0	75.4	4.3
Manyfold	24.5	90.7	4.2
Globe	1.2	77.9	4.0
Bonny Best	80.6	97.2	3.6
Chalk's Early Jewel	58.4	92.7	3.4
Stone	78.3	96.1	1.7

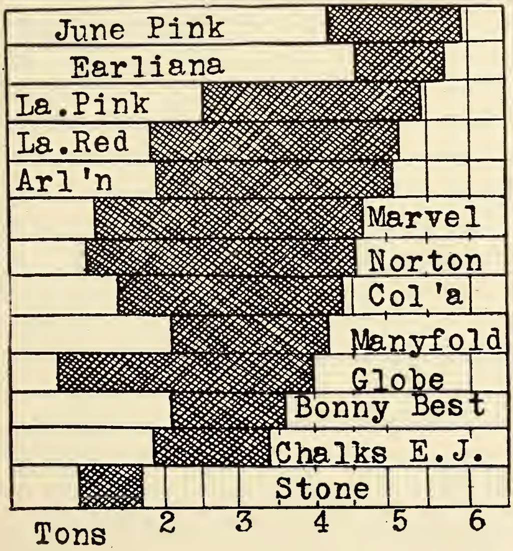

Fig. 3. The comparative yield of the different varieties in tons per acre in 1919. The unshaded portions represent the yields for the first three weeks of the picking season.

In Figure 3, the comparative yields for 1919 are presented in a graphic manner. The total yield of each variety and the yield of the first three weeks, June 7 to June 28, are shown.

From the results it is seen that the early varieties, June Pink and Earliana, gave the highest yields for the season. This was largely due to the short picking season. These early varieties produced a large portion of their fruit during the first three weeks before the later varieties had come well into bearing. Of the selected resistant varieties, the two Louisiana strains produced the most. The commercial susceptible varieties, Bonny Best, Chalk's Early Jewel and Stone, produced the least, and of the three, the Stone was decidedly the poorest. The Manyfold, an early semi-resistant variety, produced but slightly less than most of the selected varieties. The Globe, a resistant commercial variety, produced a good late crop but the total yield was rather low.

TESTS IN 1920.

In 1920, eighteen varieties were included in the tests. These were the two Louisiana selections; the four wilt-resistant selections from the United States Department of Agriculture; two wilt-resistant selections from J. A. Elliott, of the Arkansas Experiment Station, listed as Arkansas No. 1 and Arkansas No. 2; one wilt-resistant selection from S. H. Essary, of the Tennessee Experiment Station, listed as Tennessee Resistant Beauty; and some commercial varieties obtained from the Columbus, Ohio, seed store. Both greenhouse and field tests were made.

The greenhouse test was started on May 13. All varieties were included in this except the two Arkansas selections, seed not being available for these. The test ran forty-eight days, the wilt percentage being obtained at intervals of a week or less. In Figure 4, the wilt percentage of the different varieties is represented by curves as in the preceding year. The curves for the selected varieties are made with broken lines, and for the commercial varieties, with continuous lines. The two Louisiana strains and the Marvel showed the least wilt, while a number of the commercial varieties showed the most. A number of the selected strains, together with the Globe, Manyfold and Earliana, were somewhat intermediate between these two extremes.

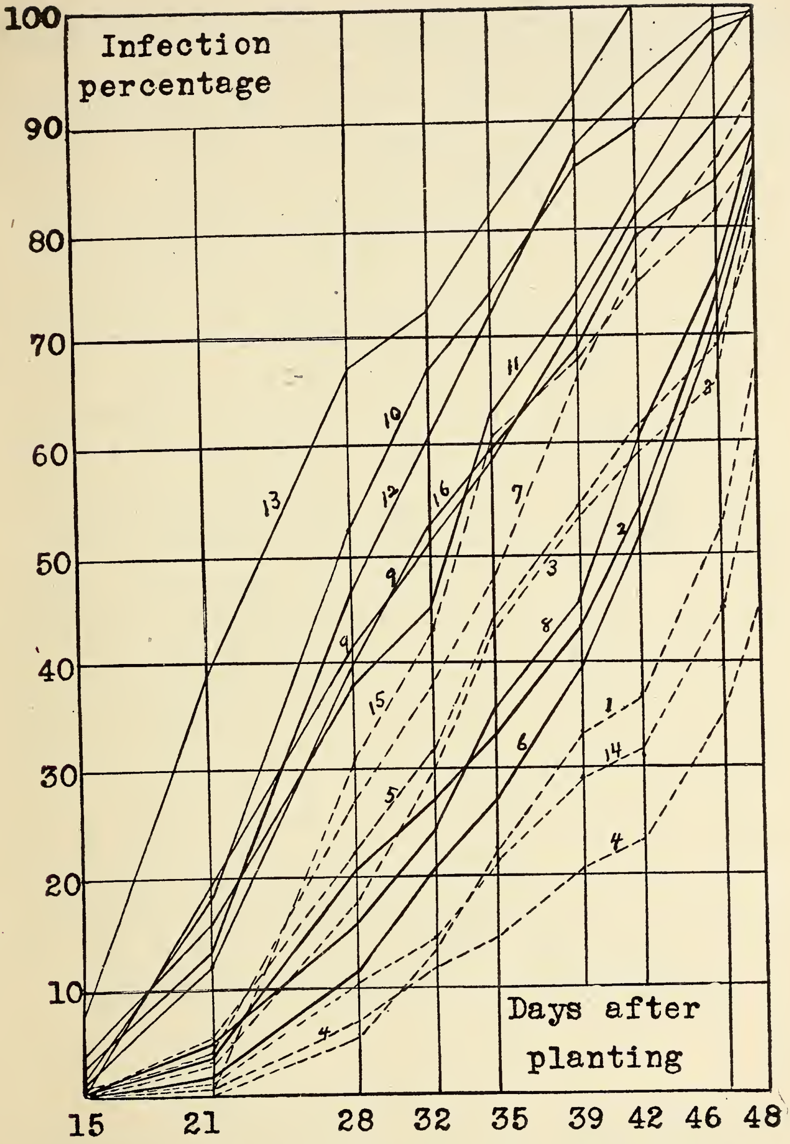

Fig. 4. Curves showing percentage of wilt in different varieties in the greenhouse, 15 to 48 days after planting; test started in May, 1920. Selected resistant varieties are represented by broken lines; commercial varieties, by continuous lines. (1) Louisiana Pink; (2) Globe; (3) Norton; (4) Louisiana Red; (5) Arlington; (6) Manyfold; (7) Tennessee Resistant Beauty; (8) Earliana; (9) Acme; (10) Stone; (11) Chalk's Early Jewel; (12) Greater Baltimore; (13) Early Detroit; (14) Marvel; (15) Columbia; (16) Redfield Beauty.

In the field test, which consisted of three rows of each variety, the wilt percentage was obtained at weekly intervals, beginning on May 18, and continuing until the plants were cut on July 23. The wilt percentages on different dates are presented in Figure 5. Five of the varieties are not included in this Figure on account of making the curves too close together. Of those omitted, the curve for the Redfield Beauty, followed very closely those of the Stone and Chalk's Early Jewel, curves 10 and 11; the curves for the two Arkansas varieties and the Marvel followed very closely those of the Norton and Louisiana Red, curves 3 and 4; while the curve for the Columbia variety was close to, but slightly higher than that of the Arlington, curve 5.

The curves for the different varieties, shown in Figure 5, are in two well defined groups. One group contains all of the susceptible, while the other contains the resistant and the semi-resistant varieties. In the latter group, the semi-resistant varieties, Manyfold, Arlington, Columbia and Tennessee Resistant Beauty, show a higher percentage of wilt than the rest. During the early part of the season, the wilt developed very slowly in the resistant varieties but in the susceptible varieties there was a rapid increase from the first. The curves for the resistant and susceptible varieties are decidedly different. The two Louisiana strains, the two Arkansas strains, the Globe, Norton and Marvel showed the least wilt in this test.

The yield of the different varieties was obtained as in the preceding year. The first tomatoes were picked on June 12 and the last on July 23, a period of between six and seven weeks. The results are shown in Table 2 and Figure 6. The table includes the total yields estimated on an acre basis and the wilt percentages at the middle and end of the picking season.

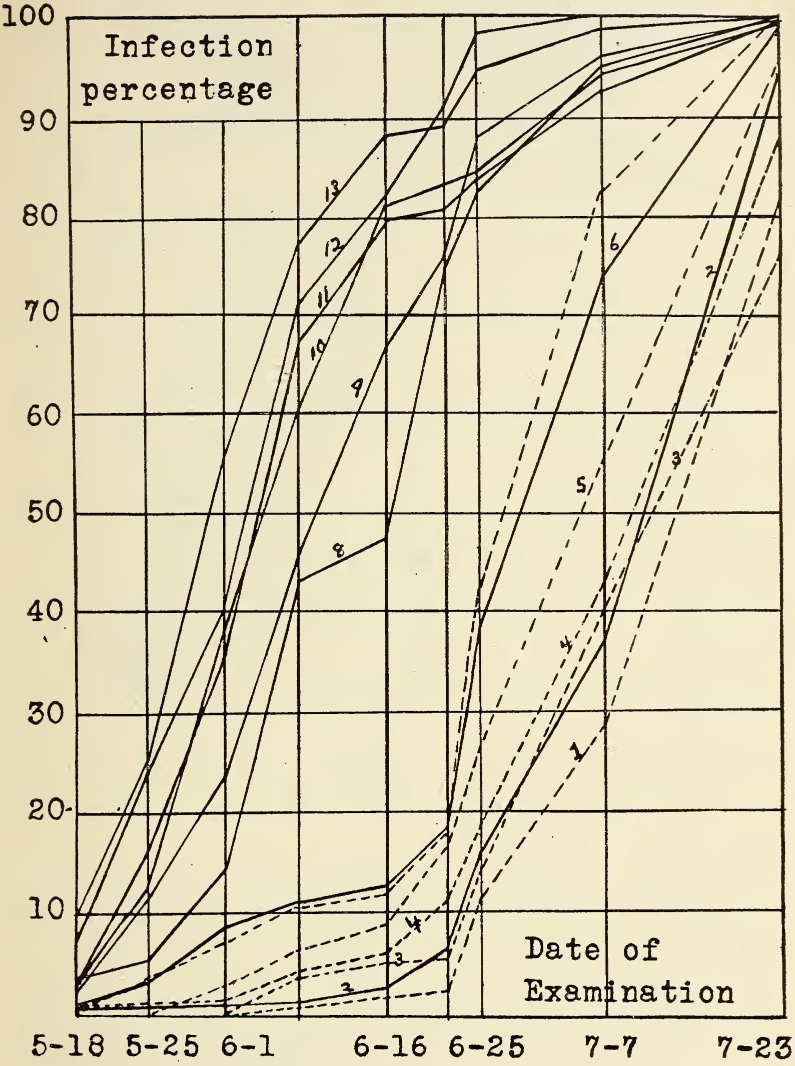

Fig. 5. Curves showing percentage of wilt in the field at different dates in 1920. Selected resistant varieties are represented by broken lines; commercial varieties by continuous lines. See Fig. 4 for names of varieties.

TABLE 2

Comparison of the Different Varieties in the Field in 1920.

VARIETY	Apparent Wilt Percent June 25.	Actual Wilt Percent by Cutting, July 23.	Yield, Tons per Acre
Louisiana Pink	12.7	84.4	8.13
Louisiana Red	19.1	88.1	7.66
Manyfold	40.0	98.0	7.24
Globe	17.0	92.8	6.00
Earliana	84.0	100.0	5.85
Norton	14.7	76.0	4.69
Marvel	18.7	78.7	4.26
Chalk's Early Jewel	85.0	99.0	3.91
Arkansas No. 2	13.3	88.7	3.89
Tennessee Resistant Beauty	40.0	98.6	3.85
Columbia	28.5	93.0	3.62
Arkansas No. 1	13.1	72.5	3.08
Arlington	31.3	96.0	3.07
Acme	88.0	99.3	2.94
Redfield Beauty	84.7	100.0	2.31
Early Detroit	95.3	100.0	1.53
Stone	84.6	98.0	1.51
Greater Baltimore	98.0	100.0	1.40

In Figure 6, the yields of the different varieties in 1920 are shown graphically. The graphs show the total yields and also the yields for the first three weeks of the picking season, from June 12 to June 23.

In the 1920 test, the Louisiana strains gave the largest yields and the Manyfold, a semi-resistant early variety, was next. The Earliana and Globe produced practically the same amount but the Earliana made the larger portion of its fruit during the first three weeks, ahead of the serious wilt development. The other wilt-resistant selections were intermediate in yield between the Louisiana strains and the susceptible commercial varieties. None of these gave very satisfactory yields.

TESTS IN 1921.

There were seventeen different varieties in the 1921 tests. These included the two Louisiana selections; three varieties from the United States Department of Agriculture, Norton, Marvel

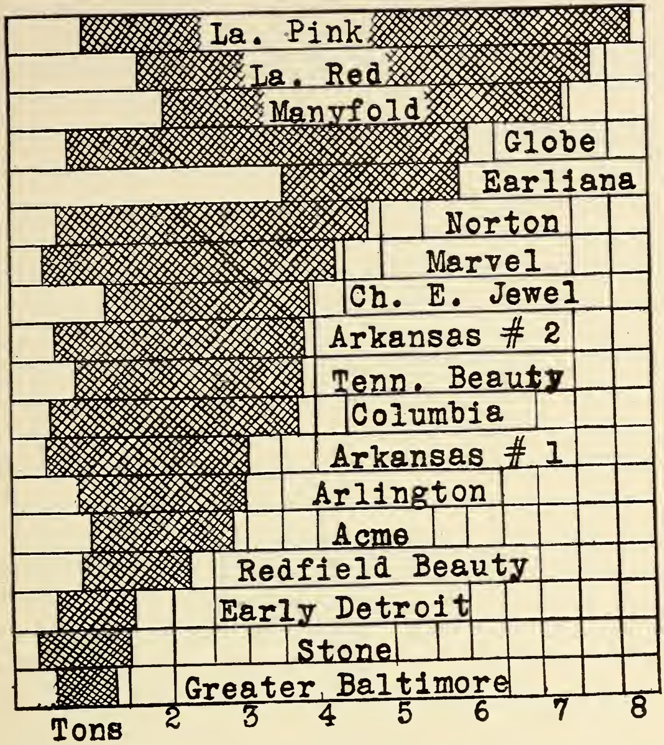

Fig. 6. The comparative yield of the different varieties in tons per acre in 1920. The unshaded portions represent the yields for the first three weeks of the picking season.

and Norduke; strains of the Norton and Marvel varieties from T. W. Wood and Son, of Richmond, Virginia; a strain of the Norton, from Twilley, of Hurlock, Maryland; two selected resistant varieties from J. P. Griffiths of the Illinois Experiment Station, New Century and Imperial; and a number of commercial varieties from the Columbus, Ohio, seed store. Only field tests were run in 1921.

With eleven of the varieties, there were planted five rows of each; with five varieties, two rows of each, and with one variety one row. As the end of the plot in which the varieties with one and two rows were placed was somewhat more fertile than the other end, the 1921 experiments are considered as two tests rather than one, and are designated as Test A and Test B. In

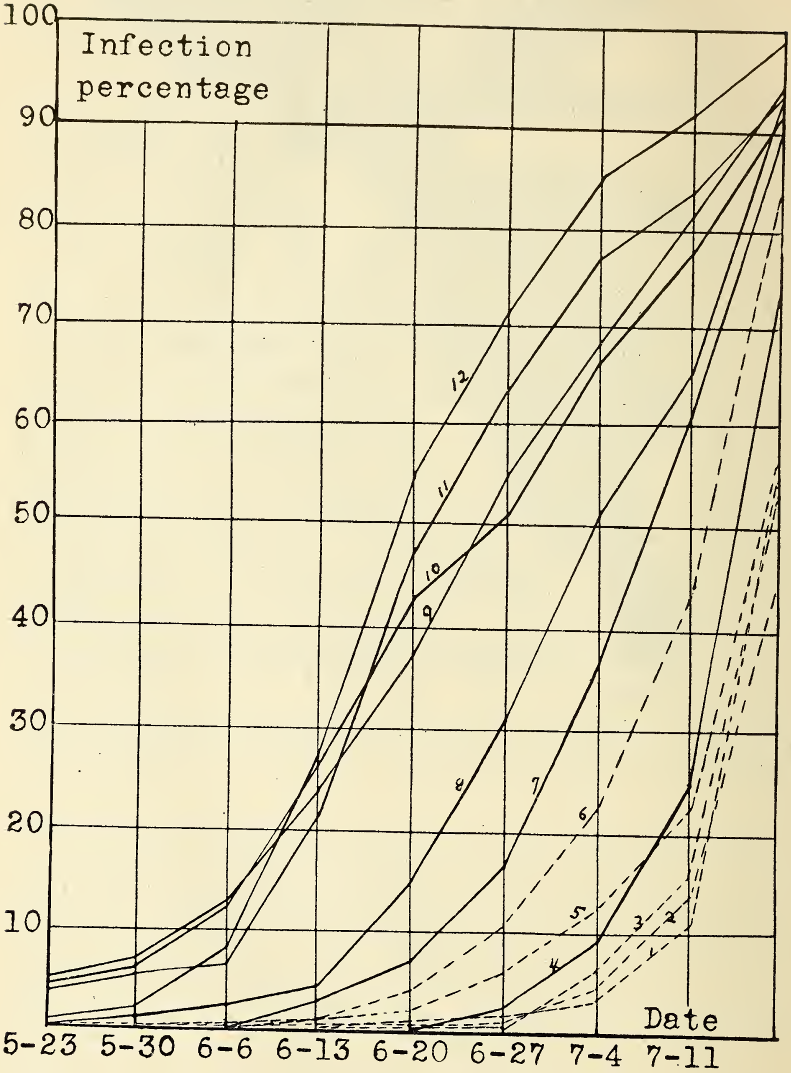

Fig. 7. Curves showing percentage of wilt in the field at different dates in 1921. Selected resistant varieties represented by broken lines; commercial varieties by continuous lines. (1) Norduke; (2) Marvel; (3) Louisiana Pink; (4) Globe; (5) Louisiana Red; (6) Norton; (7) Manyfold; (8) June Pink; (9) Stone; (10) Chalk's Early Jewel; (11) Ponderosa; (12) Earliana.

Test A, are included all varieties with five rows, while in Test B, are included the varieties with one and two rows and the corresponding two rows of some of the other varieties that are needed for comparison.

The wilt percentage in the field was obtained at weekly intervals, beginning on May 23 and ending on July 18. As in the preceding years, the percentage on the last date was obtained by cutting the plants, while for the earlier dates, it was obtained by counting the plants with evident wilt symptoms. The wilt percentages of all varieties included in Test A and one variety in Test B, the Ponderosa, are shown by curves in Figure 7. The Ponderosa is included because many people like to grow this variety and it is desirable to show its extreme susceptibility to the wilt. As in preceding years, the curves are divided into two groups, one group with the resistant and semi-resistant varieties and the other with the susceptible ones. The Manyfold is again seen to be semi-resistant. The June Pink has a better place in this test than would be expected from past experiences. With commercial varieties, it is possible that different lots of seed will not produce plants with the same susceptibility.

The yields of the different varieties were obtained as in previous years. In Table 3 are given the results of Test A, the test with those varieties with five rows. The actual yields are given and also the yields estimated to a perfect stand. The latter estimates seem desirable because with some of the varieties, the stand was not good. A series of frosts during the middle and last of April, after the plants were set in the field, killed some of the plants. The plants were reset but in some cases, they had to be reset with weak plants and a perfect stand was never obtained. The table also includes the actual number of plants that lived. In a perfect stand there would have been 325 plants. The table shows, also, the wilt percentage during the middle and at the end of the picking season.

TABLE 3

Comparison of the Different Varieties in the Field in 1921, Test A.

VARIETY	Total No. of Plants	Apparent Wilt Percent, June 27.	Actual Wilt Percent by Cutting, July 18.	Yield in Tons per Acre	Yield Estimated to Perfect Stand.
Louisiana Red	303	6.6	57.7	7.38	7.92
Louisiana Pink	298	1.3	53.0	7.03	7.68
Manyfold	299	18.3	90.6	6.04	6.55
Earliana	322	70.2	99.7	5.20	5.25
Marvel	313	1.9	44.4	4.99	5.16
June Pink	234	30.7	94.0	3.75	5.14
Globe	222	3.6	74.3	3.24	4.74
Norton	324	10.8	83.3	4.37	4.38
Norduke	315	1.9	54.9	3.59	3.70
Chalk's Early Jewel	285	50.2	92.0	2.85	3.26
Stone	257	55.6	94.2	1.55	1.95

The results of Test A are also shown in a graphic manner in Figure 8.

Again in 1921 the Louisiana strains yielded more than the other varieties tested. These varieties were followed by the Manyfold and Earliana. As usual, the Earliana produced a large portion of its fruit during the first three weeks. The selected strains from the United States Department of Agriculture were again intermediate in yield between the Louisiana strains and the commercial susceptible varieties. As usual, the Stone yielded the least.

The results of Test B, the test containing varieties with less than five rows, are shown in Table 4. In this test were included three Norton strains from different sources, two Marvel strains, two wilt-resistant selections from the Illinois experiment station and the varieties, Ponderosa, Louisiana Red and Stone. The two latter varieties were included for comparison as these made the highest and lowest yields in Test A. The yield for these two varieties was based on the two rows, located in the same part of the plot as were the other varieties in Test B. The wilt percentages at the middle and at the close of the picking season are also included in the table.

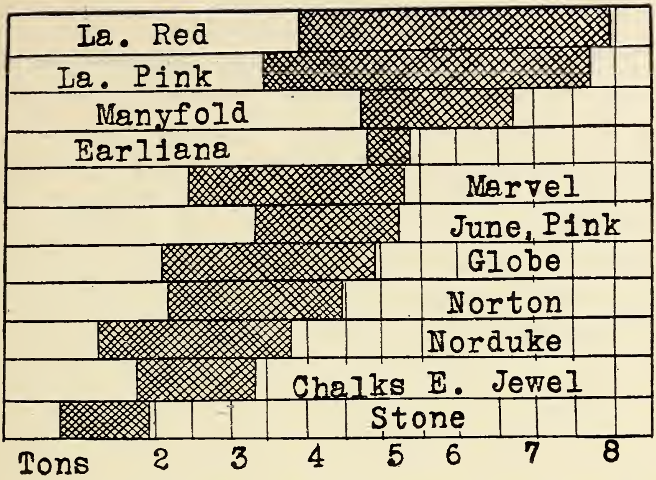

Fig. 8. The comparative yields of the different varieties in Test A in tons per acre in 1921. The unshaded portions represent the yields for the first three weeks of the picking season.

TABLE 4

Comparison of Different Varieties in the Field in 1921, Test B.

VARIETY	Total No. of Plants	Apparent Wilt Percent, June 27.	Actual Wilt Percent by Cutting, July 18.	Yield in Tons per Acre	Yield Estimated to Perfect Stand.
Norton (Twilley).......	119	28.6	90.0	3.66	4.00
Norton (Wood).........	127	16.5	94.5	5.58	5.72
Norton (U. S. D. A.)....	127	13.4	92.1	4.96	5.07
Marvel (Wood).........	121	0.9	35.5	4.87	5.20
Marvel (U. S. D. A.)....	127	2.4	62.2	5.78	5.91
New Century..........	105	6.7	84.8	4.32	5.35
Imperial..............	94	1.1	63.8	3.52	4.87
Ponderosa (one row)....	57	63.2	94.7	2.20	2.51
Louisiana Red..........	122	4.1	61.4	7.95	8.46
Stone.................	114	65.8	97.4	1.65	1.88

The results in Test B show that all of the Norton and Marvel strains and also the Illinois selections were intermediate in yield between the resistant Louisiana Red and the very susceptible strains represented by the Stone. The Marvel and Illinois strains showed less wilt than the Norton. One of the Norton strains showed a rather high percentage of wilt for a resistant strain and the yield was consequently lower than for the rest.

TESTS WITH GROWERS.

For a number of years, a considerable amount of seed of the Louisiana Red and Louisiana Pink strains has been sent out to various growers over the State. This seed has always given satisfactory results, but until 1921 no visit was made to any of the plantings. In 1921, selected lots of seed containing the two Louisiana strains, three of the strains from the United States Department of Agriculture and the commercial varieties, Globe, Earliana, Manyfold and Stone were sent out to several Home Demonstration Agents in various parts of the State, for trial. These tests were not confined to regions where the wilt was severe but the tomato varieties were sent to all sections of the State. Unfortunately, these tests were not all carried out as desired. In fact, the tests which were carried out according to directions were all in sections of the state where the wilt is of little importance. An attempt was made during the summer to visit the different localities and make a study of the value of the different varieties.

TEST AT HOUMA, LA.

A trial was made with the nine varieties at Houma, Louisiana, under the direction of the Agent, Mrs. L. J. Barrios. The test was made on the heavy black alluvial soil, common to that region. Unfortunately, all the varieties were not planted together. The two Louisiana selections were planted on a canal levee, while the other varieties were planted in a garden behind the levee. Tomatoes had been grown on the levee the preceding year but none had been grown in the garden. The soil on the levee was considerably more fertile and better drained than that in the garden.

The test was visited on June 9, the same day that the first picking of fruit was made. No wilt was found in the varieties in the garden and only one affected plant was found on the levee. The plants were all large and thrifty. There was a small amount of early blight and mosaic but not enough to injure the plants. No records were made of the yields but from observations it appeared that the Manyfold, Globe and Stone were more heavily loaded than the other varieties in the garden, while the Norduke had the least fruit. However, the two Louisiana strains on the levee had considerably more fruit than any of the varieties in the garden. As has been stated, however, these varieties were more favorably located than the others. From appearances, these plants produced considerably more than did the same varieties in the tests at Baton Rouge.

TEST AT ROSELAND, LA.

Another test was made at Roseland, in Tangipahoa parish. The soil was sandy and of the ordinary pine woods type. The season was very dry and the tomatoes did not have a chance. At the time a visit was made to the field on June 30, about the third week of the picking season, the plants were suffering from dry weather and also from a very severe attack of the early blight, (*Macrosporium solani*). At that date most of the plants were almost entirely defoliated by the blight. There was some wilt scattered throughout the field but there was not enough to give any idea of the resistance of the different varieties in that section. Miss Lettie Ensign, who had charge of the experiment, kept a record of the yield. The first picking was made on June 9. The yields of the different varieties to June 30 were as follows:

Earliana	77 lbs.
Manyfold	69 lbs.
Louisiana Red	48 lbs.
Louisiana Pink	40 lbs.
Marvel	29 lbs.
Globe	22 lbs.
Stone	16 lbs.
Norton	12 lbs.
Norduke	6 lbs.

On account of the dry season and early blight, the two early varieties yielded more than any of the others.

TESTS IN MADISON PARISH.

Two tests, one at Tallulah and one at Mounds, were made in Madison parish, under the direction of Miss Rebecca Whitaker. These were on heavy alluvial soil, very rich but unfavorable for the development of the tomato wilt. They were visited on July 21, during the third week of the picking season. Only scattering plants were found that were affected with the wilt. The most serious disease in that region was the Sclerotium wilt disease, caused by the fungus, *Sclerotium rolfsii*. Many of the plants were affected with this fungus. On account of the very rich soil, all of the tomato plants were very large. Both tests were very similar in appearance.

Mrs. George A. Yerger, who conducted the test at Mounds, measured the tomatoes picked from the different varieties. Up to June 21, the varieties had yielded as follows:

Manyfold	4.5 bu.
Louisiana Pink	4.0 bu.
Louisiana Red	3.25 bu.
Globe	2.5 bu.
Marvel	2.5 bu.
Norton	1.75 bu.
Earliana	0.5 bu.
Stone	0.5 bu.
Norduke	0.5 bu.

The two Louisiana strains produced very well and were only exceeded by the Manyfold. For some undertermined reason, the Earliana did not make the yield in this test that it has in various others. The Stone also did much poorer in this test than did various other plantings of Stone in that section of the State. In fact, in the same garden with the above test, there was another plot of Stone, planted at a different date and from a different lot of seed, that was heavily loaded with fruit.

TESTS AT OTHER PLACES.

The seed of the different varieties sent to Shreveport for a test were given out to different people and so no comparison could be made. However, a visit was made to one of the gardens in Shreveport, where the Louisiana strains were planted. In this garden, the owner had been unable to grow tomatoes on account of the wilt. The Louisiana strains were growing well and the plants were heavily loaded with fruit.

At Avery Island, there was planted a small plot of the Louisiana Red tomato. At this place the growers have had serious trouble in raising tomatoes on account of the wilt. This plot was seen in the midst of the picking season. There was only a small amount of wilt and the plants were all heavily loaded.

DISCUSSION OF RESULTS.

There are a number of more or less evident conclusions which can be drawn from the tests which have been described.

1. The wilt disease attacks all tomato varieties but it kills the susceptible plants much quicker than it does the resistant ones. Wilt development is much slower in resistant varieties during the early part of the season, while the plants are growing vigorously than it is in susceptible varieties. This is shown by the various curves in this bulletin, showing wilt development in the field. After the plants become older and possibly weakened by the production of the fruit, the wilt development in the resistant varieties seems to be accelerated.

2. Small plants of the resistant varieties have shown the same resistance to the disease in infested soil in the greenhouse as have older plants in the field. In this respect, the tomato wilt differs from the cabbage yellows, a very similar disease of cabbage. In a recent publication of the Wisconsin Experiment Station*, it is claimed that small seedlings of the most resistant cabbage varieties succumb very readily in a sick soil.

3. Most commercial varieties of tomatoes are very susceptible to the disease though there are some exceptions. The Globe is remarkably wilt resistant. Then there are a few commercial varieties, such as the Manyfold, that are somewhat semi-resistant. These semi-resistant varieties are more or less intermediate between the resistant and the susceptible varieties. In the tests described in this bulletin, some of the commercial varieties, especially the Earliana and June Pink, have shown variation in regard to their resistance, sometimes being in the susceptible class and sometimes in the semi-resistant class. Whether this was due to the fact that different lots of seed were used for the different tests or to the local weather conditions, was not definitely ascertained.

4. The wilt percentage during the middle of the picking season shows the comparative wilt resistance of the different varieties. Susceptible varieties in badly infested fields usually show more than fifty per cent with wilt at that time.

5. Very early susceptible varieties, such as the Earliana and June Pink, often make a fair to good yield, even in badly infested fields. If a variety also shows slight resistance to the wilt, as does the Manyfold, a fairly good yield is nearly always obtained. The early varieties seem to be able to make a crop

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*Jones, L. R., J. C. Walker and W. B. Tisdale. Fusarium resistant cabbage. Wisconsin Agri. Exp. Sta. Research Bulletin 48: 26, 1920.

before the wilt has time to kill the plants. However, in badly infested soils, the early varieties have not averaged the high yield of some of the best resistant varieties.

6. A number of so-called resistant varieties have been developed at a number of places in the southern and middle states. In the Louisiana tests, some of these were comparatively resistant, while others were only semi-resistant.

7. In testing out tomato varieties in any region, the comparative resistance is not the only essential factor to be considered. The yield of the varieties in that region must also be considered. A number of resistant varieties are of little value because they do not yield satisfactorily.

8. The varieties which have been developed at the Louisiana Experiment Station have been proven to be satisfactory for Louisiana conditions, both in resistance to the wilt and in their yielding ability. In all of the tests at the experiment station they have yielded considerably more than any of the other resistant varieties tried, and in two tests out of three, they have yielded more than any other variety. Furthermore, the tests with these varieties in all parts of the state, have been highly satisfactory.

9. The Louisiana selections, like other resistant varieties, are claimed to be resistant only to the one disease, the true tomato wilt. They are not particularly resistant to the bacterial wilt, the Sclerotium wilt, the early blight or the mosaic disease. They show slightly more resistance to the early blight than do some varieties like the Earliana, but they will not resist a heavy early blight infection. However, these selections are not injured more by these various diseases than are other common varieties. As the Septoria leaf spot is not common in Louisiana, no information has been obtained on the relative susceptibility of these selections to this disease.

10. Of the varieties which have been sent out by the United States Department of Agriculture, two are worthy of consideration. These are the Norton and Marvel. These varieties have not given as good yields as have the Louisiana strains but they are fairly resistant to the wilt. Of the other Government varieties, the Columbia and Arlington have not shown enough resistance to the wilt, while the yields of the Norduke have been too low.

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LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE

AGRICULTURAL EXPERIMENT STATIONS

W. R. DODSON, Dean and Director

BATON ROUGE, LOUISIANA

THE SUGAR CANE MEALY BUG
AND
ITS CONTROL IN LOUISIANA

BY
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IN COOPERATION WITH
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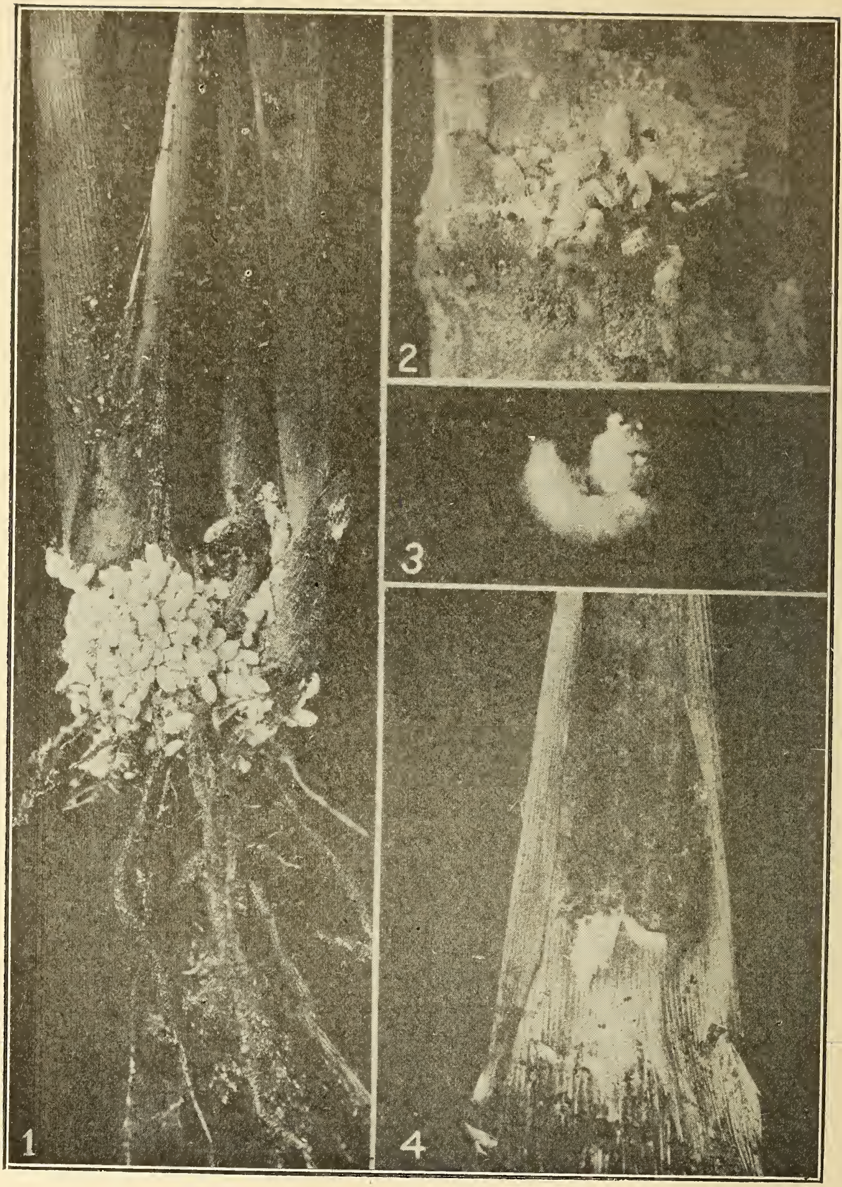
PLATE 1.



THE SUGAR-CANE MEALY-BUG (Pseudococcus Calceolariae.)
Fig. 1.—Adult mealy-bugs clustered about the base of young cane. Fig. 2.—Adult female, twice natural size. Fig. 3.—A single adult female, with white mealy-like covering. Fig. 4.—Cocoons of male mealy-bug. (Original.)

THE SUGAR-CANE MEALY-BUG AND ITS CONTROL IN LOUISIANA.

In recent years the sugar-cane mealy-bug has attracted considerable attention in the cane-belt of Louisiana. Many planters have observed with alarm the rapid development and spread of this insect on their plantations. In many instances it is thought at first to be a fungus growth owing to its white, woolly appearance on the cane-stalks. A closer examination, however, shows that this woolly material incloses countless numbers of minute eggs and that a very large number of small, many-sized, greyish insects are interspersed with the woolly substance and they are usually found clustered around the joints of the cane. Always these heavy infestations were accompanied by the Argentine ant but it was not known until quite a late date the important part this ant performed in these infestations and in the multiplication of this mealy-bug.

PRESENT INFESTATION.

By searching very carefully in a cane-field in almost any part of the cane growing area of Louisiana, it is possible to find a few of these mealy-bugs but it is only where the Argentine ant is present that they assume their overwhelming numbers. During the last twenty years the Argentine ant has been carried to practically every town in the cane-belt and from these towns it has gradually extended its area of infestation into the surrounding canefields. In each case the mealy-bug infestation has quickly developed. The invasion of the canefields by the ant continues and at this date many thousands of acres are occupied and the cane throughout these areas is invariably infested with the mealy-bug. In 1910 these conditions were found only in part of the Parishes of Plaquemines, Jefferson and Orleans in close proximity to New Orleans, the original starting point of the Argentine ant in the United States. Now these dual infestations are to be found in every parish where sugar-cane is grown in large areas. If nothing is done to check the continuous spread of the Argentine ant it will only be a matter of a few years when the whole cane-belt becomes infested. Under those conditions the loss through the mealy-bug depredations will be very great.

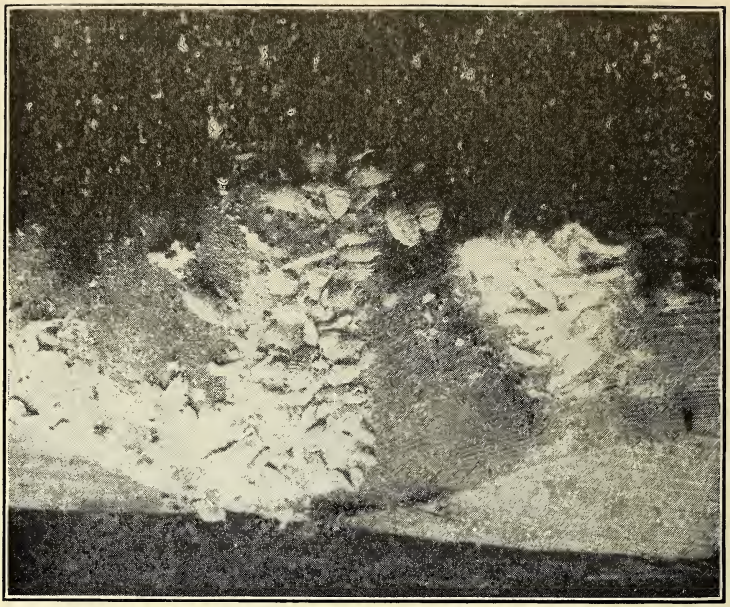


FIG. 1.

Mealy-bugs clustered on canestalk. (Natural size.) Note group of male cocoons at left.

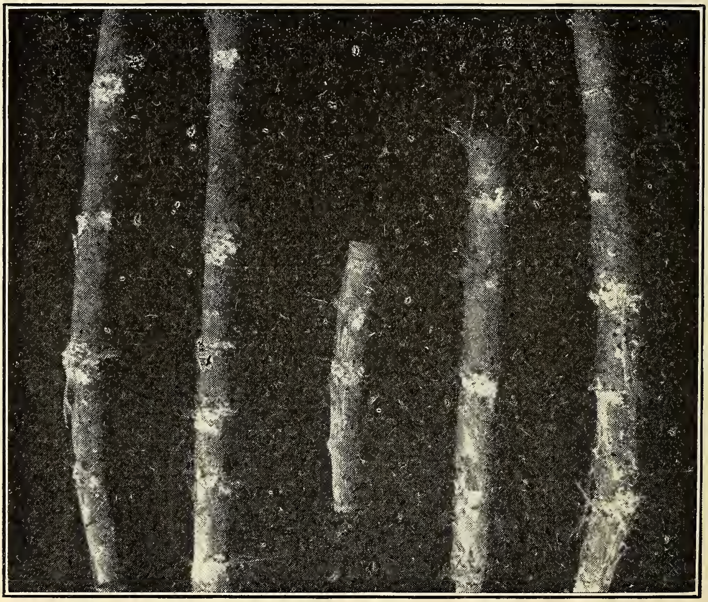


FIG 2.

Fall plant cane dug up in the spring. In this case nearly all the "eyes" were killed by the overwintering mealy-bugs.

BRIEF DESCRIPTION OF THE MEALY-BUG.

The eggs which are inclosed in the white, woolly material are oval, of a brown color and about one hundredth of an inch in length. When hatched a tiny nymph appears which is slightly longer than the egg and of a brownish-grey color. It is quite mobile and can crawl almost a foot in a minute. In the early days of this nymph stage it is difficult to differentiate between the sexes. About the seventh day, however, they separate, the male nymphs going off to themselves and spinning white cocoons. These cocoons are usually found in clusters (see plate 2, fig. 1) but occasionally they will pupate by themselves. The female nymphs continue to feed on the tender parts of the cane plant, usually collecting around the upper joints and leaf-sheaths. They do not change much in appearance except that they continue to grow. The adult females are about one-tenth of an inch long. In the process of development they become covered with a whitish, powdery secretion. Almost invariably, too, they will descend to the lower parts of the cane-stalk when they have nearly reached their mature growth. Here they will cluster around the joints and soon commence to lay eggs.

The male upon emerging from the cocoon is a tiny delicate two-winged fly. It is of a bronze color with two white anal spines. On a fine day they may be observed in quite large numbers in the midst of a heavy infestation.

A female mealy-bug when ovipositing will start by exuding the white, woolly material from her body and then lay the eggs beneath this covering. As she continues to lay she gradually moves ahead. As the egg-cluster becomes larger the female becomes appreciably smaller. In summer temperatures egg-laying will cease about the tenth day and by this time the female is so small that she becomes practically lost in the woolly secretion, (see plate 1: fig. 3). An average egg-cluster will contain about 350 eggs.

In warm weather the egg period is about four days; that of the female nymph about 25 days: the male nymph about seven days and the male pupal period about 20 days.

RELATIONSHIP EXISTING BETWEEN THE MEALY-BUG AND THE ARGENTINE ANT.

The relationship existing between the sugar-cane mealy-bugs and the Argentine ants is very unique. The mealy-bugs suck the juice from the cane and secrete a sweet, watery liquid familiarly known as "honey-dew." The Argentine ants are very fond of this "honey-dew" and in return foster the mealy-bugs in numerous ways. They carry the young nymphs to the most desirable places on the plants. They build mud shelters over them to protect them from direct sunlight, rains, storms and parasitic and predaceous enemies. By assiduously collecting the "honey-dew" they keep the mealy-bugs clean and thus, to a large extent, prevent parasitic fungi from doing serious harm. Protected in this manner the mealy-bugs are increased many hundred fold.

In experiments conducted in 1912, '13, '14 and '15, when a specific number of mealy-bugs were propagated on isolated and ant-attended cane plants, the counts in the fall were each year about ten times as great on the ant-attended as they were on the isolated plants.

Apparently the reason the mealy-bugs propagated as well as they did on the isolated cane was due to the fact that this cane was located in the midst of a heavy Argentine ant infestation and apparently nearly all of the predaceous and parasitic enemies in this region were either killed or driven off.

In the years 1918, 1919 and 1920 experiments were conducted controlling the Argentine ants over a large area of growing cane. In each of these cases the mealy-bugs were automatically controlled to such an extent that it was quite difficult to find any of them present on the cane at any time throughout the growing season. However, each year a "check" plot was set apart on which the Argentine ants were very plentiful and in these "check" plots the mealy-bug infestations were normally severe.

In Louisiana the mealy-bug is a very minor cane pest when by itself but when accompanied by the Argentine ant it becomes one of the foremost cane pests.

INJURY TO CANE.

Mealy-bug injury to cane is continuous from the period of planting or winrowing in the fall until the time of harvest the following year.

Plant cane is carefully handled and sparingly "stripped" in order that the eyes of the cane should not be injured. Furthermore, cane cut for planting is not ''topped'' so low as cane harvested for the mill. This method of handling seed cane is extremely favorable for the mealy-bugs. Large numbers are left on the stalks, especially the young nymphs which are present in thousands on the upper joints of the cane. This cane is laid in prepared trenches, in the field to be planted, soil is then plowed over it and ditches are made between the rows to carry off excess rainfall. Argentine ants build their nests in these rows (or ridges) and have dry nesting quarters for the winter. They assiduously attend the mealy-bugs on the plant cane and the mealy bugs in turn continue to extract the juice from the cane and supply their quota of ''honey-dew''. During a mild winter especially, conditions below ground are almost ideal for the propagation of large numbers of mealy-bugs and ants. The writer has often dug up seed-cane in the spring and found mealy-bugs, in all stages of development, in handfuls around the joints of the cane. (See plate 2, fig. 2.) The young nymphs, throughout the winter, select the most tender parts of the cane on which to feed, consequently they will cluster around the ''eyes'' to such an extent that many of these ''eyes'' are killed outright. ''Eyes'' not actually killed will be very much weakened and as they grow in the spring are continually preyed upon by the mealy-bugs (see plate 1, fig. 1). Many of the young shoots are killed when they have attained a considerable size (see plate 3, fig. 1). Others are weakened and impoverished and a very poor stand of cane is the result (see plate 3, fig. 2).

PLATE 3.

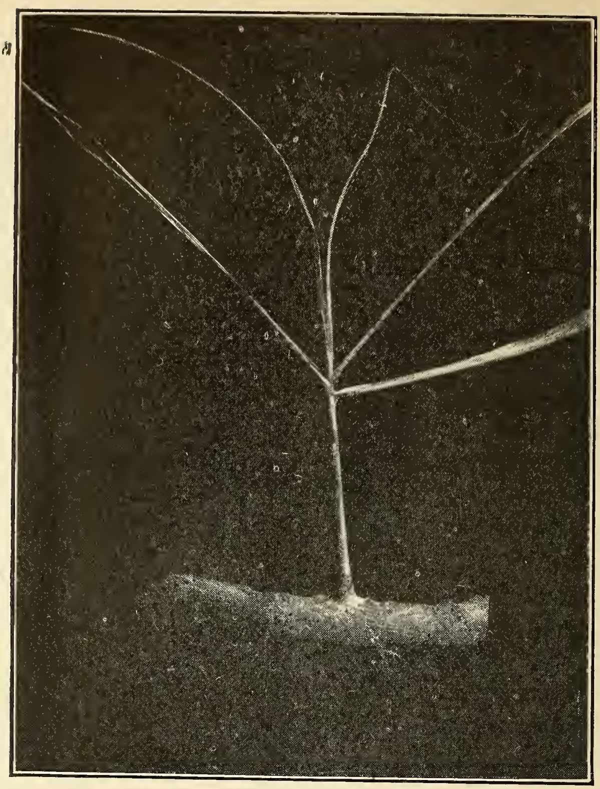


FIG. 1.

Young shoot of sugar-cane killed by the Mealy-bug. Note the cluster of Mealy-bugs at the base of this cane.

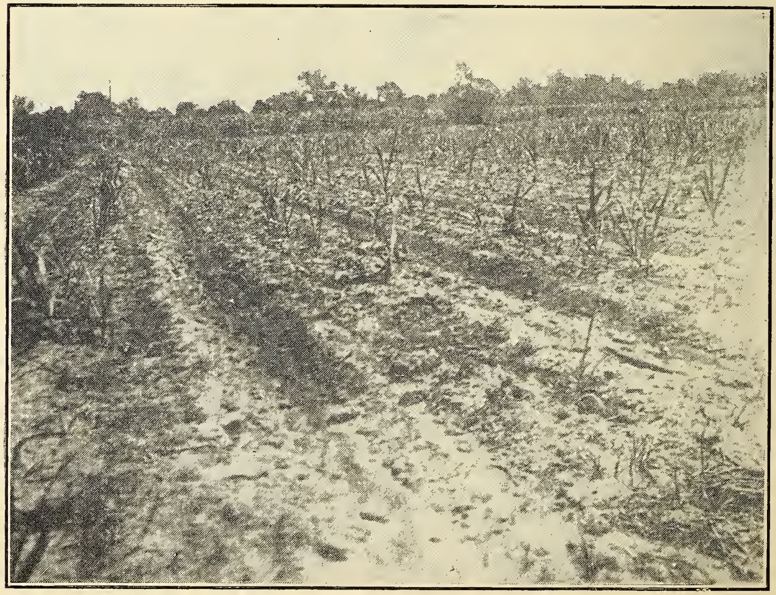


FIG 2.

A very poor stand of young cane due to the ravages of overwintering Mealy-bugs.

As the young shoots come through the ground and continue to grow, they become a splendid vehicle on which the mealy-bugs are carried above ground and through the summer these ant-attended insects continue to propagate and take a heavy toll from the growing canes, robbing the plants of vitality by extracting the juice; at the same time making the plants more susceptible to fungus diseases.

At the time of harvesting the cane for grinding, it is stripped as clean as possible. There is no need to protect the "eyes" in this operation; the stalks are "topped" lower, otherwise, the upper, watery joints would be ground in the sugarhouse at a loss. In this way most of the mealy-bugs are left in the field and very many of them find their way back to the stubble left in the ground, they descend below ground and find splendid wintering quarters on the roots of the cane (see plate 1, fig. 1).

During the years 1914 and 1915 experiments were conducted in growing cane in two plots, one isolated from the Argentine ants and kept free of mealy-bugs; the other ant-attended and supplied with a liberal number of mealy-bugs. Both plots were planted with the same variety of cane, fertilized and watered precisely alike. Each year the infested cane showed a stunted growth with fewer stalks which had more joints but the joints were shorter. The isolated cane had a stronger, healthier growth, more tonnage per acre and more juice per ton. The cane from both these plots was ground in a hand-mill, hence the extraction was very low, but equally so in each case. A composite table of the two season's results follows:

Cane	Tons per acre.	Weight of juice.	Per cent bagasse.	Total sugar per acre.	Value at $4.00 per 100 lbs.	Loss per acre.
Isolated	27.05	30325 lbs.	44.35	2274 lbs.	$90.96	$25.60
Infested	22.00	21845 lbs.	50.10	1634 lbs.	$65.36	

CONTROL OF ARGENTINE ANT IN CANE-FIELD WITH TRAP-BOXES

In the fall of 1916 an experiment was conducted with the object of controlling the Argentine ants on an entire plot at the

Sugar Experiment Station. Forty-six trap-boxes, one foot square, were used. Each box was filled with a mixture of equal parts of fresh horse manure and rice hulls and covered to keep out the rain. The contents (decomposing) created sufficient heat to make these boxes very desirable places for the ants to nest in. The boxes were placed on the plot used for the experiment, also on all surrounding plots to obtain a wider control to prevent a reinfestation in the spring.

The winter of 1916-17 was unusually cold and wet and it was very favorable for "forcing" the ants into the trap-boxes. The boxes were examined every few days, and whenever a sufficient number of ants were found present they were fumigated with carbon bisulphide. All the boxes were fumigated on Jan. 8, 19, 26, and Feb. 6 and 17. A very good control was established. In the spring very few ants could be found on any part of the controlled area.

For purposes of comparison a "check" was established about 400 yards distant. This plot was planted on the same day with the same variety of cane and both the experimental and the "check" plot received the same cultivation.

On May 8 counts were made of the number of shoots in each plot. At this time there was an average of 181 shoots per row on the experimental plot and only 97 per row on the "check" plot. On June 20 the counts were 330 and 116 respectively. On August 14 the counts were 361 per row on the experimental plot and 220 on the "check" plot. On this date the actual counts did not show the significance of the experiment. There was a much wider difference in the appearance of the two plots. The experimental plot was undoubtedly the best cane on the Experiment Station grounds while the cane on the "check" plot was only an average stand. A dry fall prevented, to a large extent, the continuance of the comparison and when harvested in December the yields were not so marked as earlier indications would have indicated. The tonnage was as follows: Experimental plot 24.1 and "check" plot 19.7 tons per acre.

The rainfall for the year 1917 was 32.27 inches as compared with the previous fifteen year average of 57.8 inches. Had the season been wetter it is very probable that the results of this experiment would have been much more marked.

While the trap-boxes worked very nicely during the winter of 1916-17, during the winter of 1918-19 they were a complete failure. This was a mild winter, very dry and the ants had such desirable nesting facilities in the rows that they did not enter the boxes except in small numbers. There were never enough of them present to warrant the use of fumigation. Thus it is evident that this system of control is not applicable every year. Furthermore, the installation of the trap-boxes is quite expensive and it necessitates continuous activity throughout the winter to inspect and fumigate the boxes. For this reason the trap-box method of control is hardly to be recommended.

CONTROLLING THE ARGENTINE ANT BY USING A SLOW POISON-SYRUP.

For a number of years the writer worked on the problem of controlling the Argentine ant in towns and cities. It was found that strong poison-syrup repelled these ants; a few of them would be killed but others recognizing the source of fatality would have nothing further to do with the "doctored" food. It was discovered, however, that a weak poison syrup would kill the ants so slowly that they could not ascertain the cause and they would continue to feed on it until extremely few ants remained alive. Furthermore, it was necessary to prepare a stable poison-syrup, one which would not crystallize, sour, decompose or quickly evaporate when exposed for long periods and especially at high temperatures. A poison-syrup made according to the following formula has been successfully used in many towns in the Southern States and also in California:

Granulated Sugar	18 lbs.
Water	18 lbs. (pints)
Tartaric acid (crystallized)	12 grams
Benzoate of Soda	16.8 grams

Bring these ingredients to a boil and keep boiling very slowly for 30 minutes then allow to cool.

Next—Thoroughly dissolve 30 grams Sodium Arsenite ($Na\ As\ O_2$) *pure* in one pint of hot water. Cool and add to the cooled syrup. Add also 2½ lbs. good honey and mix thoroughly.

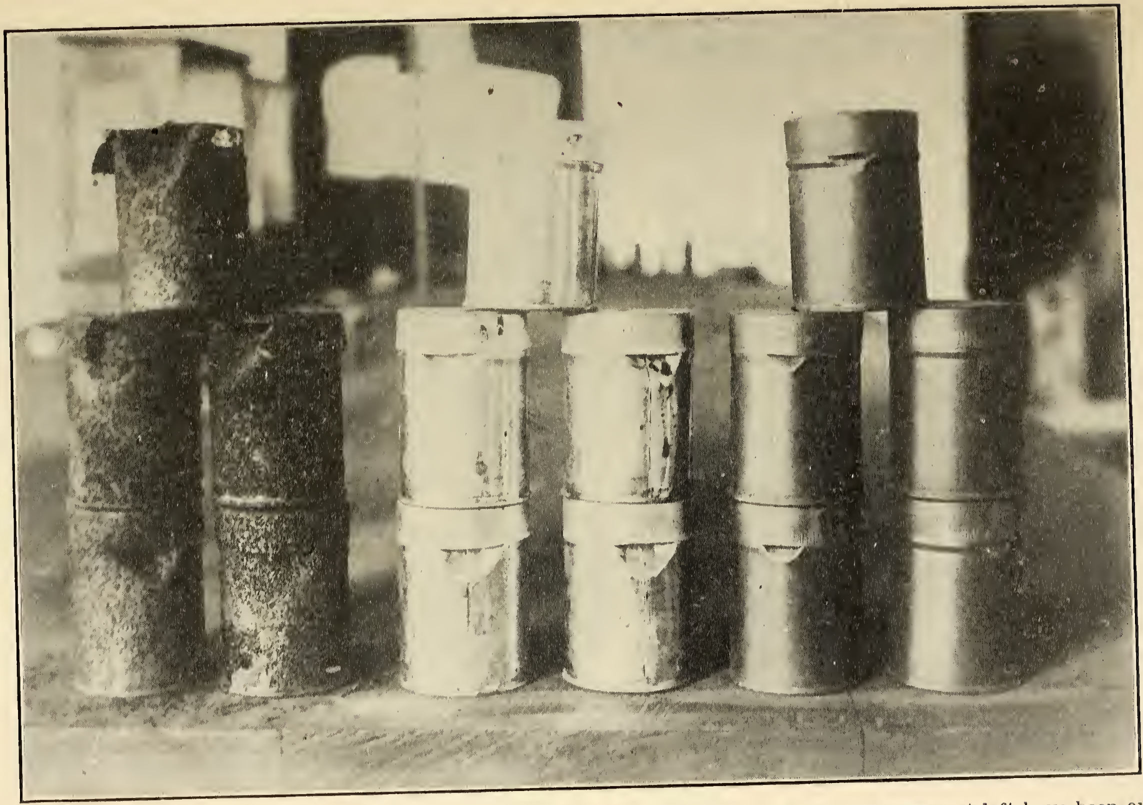
During the winter of 1918-19 an extensive ant-control experiment was undertaken using this poison-syrup for the controlling factor. This experiment took in an area of about twenty-five acres and included almost all the cane plots on the Experiment Station grounds. The only cane plots not included were used for "checks" and for a trap-box experiment, previously mentioned.

From experience in city campaigns it had been found that a can container in which to place out the poison-syrup is most economical; a 4 oz. baking powder can being especially convenient for this purpose. This can holds about two gills of syrup but in an ordinary Argentine infestation one gill per can is sufficient. A small piece of cheap, "grass-form" sponge is placed in the can. It floats on the syrup allowing the ants to enter the can en masse, to fill themselves with the syrup and carry it to the nests to feed the "queens" and immature stages. The action of the sponge is entirely mechanical, it should, however, be washed clean and dried before used.

Two opposite sides of the can are deeply indented and when the lid of the can is forced on, there remains ample room for the ants to enter under the lid where the indentation has been made. If this can is hung in an upright position it will be weatherproof. (Plate 4 shows cans prepared, ready to place out in the field.)

About 25 cans were placed out to the acre. They were hung on stakes about two feet long which were pointed and shoved into the ground, along the rows, ditch-banks and headlands. A square piece of board, about 8 inches each way, was nailed on top of the stake and the can hung directly under it. It served to protect the can from rain and direct sunshine. When exposed to direct sunshine the syrup will be unduly evaporated. It was previously stated that this poison-syrup is very slow to evaporate due to the fact that the sucrose is partially inverted by the addition of tartaric acid and prolonged boiling; however, it is best to retard evaporation as much as possible so that the poison content will remain at or near normal. Furthermore, the Argentine ants detest sunlight and they will attend the cans to a much greater extent when they are hung in the shade. A nail is driven into the stake (on which the can is hung), at an angle of about 60 degrees in an upward direction. The hole made by the indentation on one side of the can is then forced over the head of the nail and the can is securely attached to the stake.

PLATE 4.



Cans used for putting out poison-syrup in canefield. New cans shown in center, rusty cans at left have been exposed for one year. They are of no further use. Enamelled cans, at right have also been exposed for one year and still as good as new.

The results of this ant-control experiment were very gratifying. In the spring very few ants could be seen anywhere on the controlled area and in the fall following it was extremely difficult to find either ants or mealy-bugs on the cane in these plots. Both the Argentine ants and mealy-bugs were found as numerous as ever on the "check" plots.

This experiment was duplicated during the winter of 1919-20 on most of the newly planted cane. However, all the "stubble" cane was left to ascertain results if the ants were left uncontrolled for a year. This duplicate experiment was equally as satisfactory as the one conducted in the previous year, the ants were reduced to a very small number and the mealy-bugs were difficult to find on the cane in the ant-controlled plots. Both insects were very plentiful in the "check" plots. In the stubble-cane area the findings were very satisfactory, extremely few ants or mealy-bugs were present on the cane despite the fact that a year had elapsed since control measures had been applied to this area.

COST OF ARGENTINE ANT AND MEALY-BUG CONTROL BY USING POISON-SYRUP.

In normal times the total cost of materials, preparation and applying the poison-syrup is about $42.75 per 1000 cans, which will be sufficient for forty acres. In other words the cost is slightly in excess of one dollar per acre. Itemized it is as follows:

1000 four oz. cans	$12.00
125 lbs. Granulated Sugar at 5c per lb	6.25
Chemicals (about)	2.00
8 lbs. Sponges at 25c per lb	2.00
4 gals. Honey at $2.00 per gal	8.00
Labor	12.00
Total	$42.75

Under ordinary conditions the tin cans will rust out and become useless in less than a year, consequently it is advisable to paint the outside of the cans. They do not rust on the inside. A gallon of green "screen" enamel costing $2.80 will be sufficient to paint about 3000 cans. At a cost of less than $5.00 per thousand cans, including labor of painting, the cans will be preserved so that they will last a number of years. Plate 5 shows the new cans, center; rusty cans that have been exposed for a year, at left; and enamelled cans, that have been hung out for a year, at right. These enamelled cans are as good as the first day they were placed out.

THE BEST TIME OF THE YEAR FOR PLACING OUT THE ANT-POISON.

Undoubtedly the best time of the year for putting out the poison-syrup is in the fall soon after the cane has been planted. Then the mealy-bugs are at their minimum numbers and the ants will be short of their natural food (''honey-dew''). Any time between planting and the middle of February will be fairly satisfactory. A great objection to the later application is that the cans have to be moved from one row to another when the early spring work begins. When the control is put on in the fall the cans can be collected and put away before the spring work begins. Ants should also be controlled over the area of winrowed and ''stubble'' cane.

After the Argentine ants have been controlled it would be well to place out a few cans of the poison-syrup each year over the area controlled. Eight or ten cans per acre would be sufficient. The object is to aim at total eradication of the Argentine ant. The writer believes this to be possible if the work is persistently kept up for several years.

NATURAL ENEMIES OF THE SUGAR-CANE MEALY-BUG.

The sugar-cane mealy-bug has a number of natural enemies which very efficiently control it if permitted to do so.

There are several species of native ladybeetles, the larvæ and adults of which greedily devour the eggs, nymphs and adults of the mealy-bugs. A Hymenopterous and several species of Dipterous internal parasites have been found to do effective work.

In damp weather an Aspergillus fungus does splendid control work especially when the ''honey-dew'' remains on the mealy-bugs and plants, giving the fungus spores a culture to grow in as well as a sticky surface on which to attach, when spread by the wind and rain.

Other predatory insects undoubtedly aid in suppressing the mealy-bug once the Argentine ant has been removed.

THIS METHOD OF CONTROL APPLICABLE TO LOUISIANA CONDITIONS.

It may be well to state here that the sugar-cane mealy-bug is an imported pest and that in some other cane-growing countries, where the Argentine ant is not present, it is a pest due to its relations with some species of native ants in those countries. Very few native ants are to be found in Louisiana canefields. The writer has never observed any of our native ants living harmoniously with this mealy-bug.

SUMMARY.

(1) The sugar-cane mealy-bug is a minor cane pest in Louisiana where the Argentine ant is not present but becomes a very injurious pest when protected by this ant.

(2) When the Argentine ant is controlled the mealy-bug is automatically controlled by its natural enemies.

(3) It has been found that a weak, poison-syrup is the most practical method for controlling the Argentine ant. This poison-syrup is placed out in the canefield in cans, using about 25 cans to the acre.

(4) The cost of such a control in normal times is slightly more than one dollar per acre.

(5) The best time to place out the poison-syrup is as soon after fall planting as possible, though if placed out at any time before the middle of February the results will be satisfactory.

(6) Cans should be hung up and protected from the sun to arrest evaporation and to permit the ants to work in the shade.

(7) It is economical to enamel the cans to prevent their destruction by rusting. They may be used year after year but should be cleaned and recharged each year before they are replaced in the field.

TECHNICAL

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LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE

AGRICULTURAL EXPERIMENT STATIONS
W. R. DODSON, DEAN AND DIRECTOR

BATON ROUGE, LOUISIANA

SECOND PRELIMINARY REPORT ON PARASITES FOUND IN RUMINANTS AT THE MUNICIPAL ABATTOIR, BATON ROUGE, LA.

BY
G. DIKMANS, B. S. A., D. V. M.
PARASITOLOGIST

SECOND PRELIMINARY REPORT ON PARASITES FOUND IN RUMINANTS AT MUNICIPAL ABATTOIR, BATON ROUGE, LA.

By

GERARD DIKMANS, B. S. A., D. V. M., Parasitologist.*

The work in Parasitology at the Experiment Station was begun, in a systematic manner, in September, 1920, the primary object being to ascertain, as far as possible, the different types of internal parasites with which farm animals in Louisiana are infested.

Being comparatively new, as a special department of the Experiment Station, the work, at the beginning, was considerably handicapped through the lack of the necessary laboratory equipment, and literature for reference.

The work had a two-fold object in view, viz., (1) to obtain some data on the internal parasites of domestic animals in Louisiana; and (2) to afford the writer an opportunity to familiarize himself with the morphology and pathology of the parasites found.

In order to gain the desired information as readily as possible, he was able to make use of the opportunities furnished by the local municipal abattoir, which was kindly placed at his disposal by the city authorities.

Such material collected at the abattoir, as was thought desirable for examination, was brought to the Station laboratory for that purpose. The entire intestinal tract of one or two animals was taken, the various parts washed out separately, and the washings examined for the presence of parasites, which is considered the best method of procedure, as it gives the fullest information on

(a) The types of parasites,
(b) The number of parasites,
(c) The frequency or percentage of infestation,
(d) The relative number of males and females, etc.

Owing to the conditions prevailing consuming too much time, however, a change of procedure was thought advisable, and the work was afterwards divided into four stages, viz.,

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*Resigned September, 1922.

(a) Examination of the stomach contents,
(b) Examination of the contents of the small intestine,
(c) Examination of the large intestine,
(d) Examination of the liver, lungs, esophagus, etc.

Washing of stomachs was transferred from the laboratory to the abattoir, and as many as could be conveniently handled were selected and examined, an attempt being made to keep separate those of calves and of grown animals, although this was not entirely successful on account of the method of slaughtering. It was then decided to adopt the method outlined by Hall, in paper No. 119 from the Research Department of Parke, Davis & Co., Detroit, Mich., for the washing of stomachs, viz., washing the contents on a series of sieves varying in mesh from 16-100.

During the vacation of 1921 (being engaged with class work during the College session), the writer was enabled to spend six weeks at the Zoological laboratory of the Bureau of Animal Industry, Washington, D. C., with Drs. Ransom & Hall, two of the foremost helminthologists in the United States.

The writer took with him, for identification, some of the material he had collected in Louisiana, as some of it differed materially from the descriptions given in published reports.

It was while in Washington that the species of stomach worm, described in Bulletin No. 183 of this Station, was identified, and its occurrence, which had previously been reported only for South America and Europe, recorded for the United States.

From publications available in the Washington laboratory, several apparent anomalies of the vulval process of the common stomach worm, *Hæmonchus contortus,* were also recognized as normal. These features, because of the lack of literature at the Station, had hitherto presented a difficulty in identification. Several interesting points in technique were also acquired while in Washington.

The material collected at the local abattoir, which has been preserved in vials and numbered up to 32, represents that from the stomachs of approximately 200 cattle, and will be found to contain several specimens of the Family *Strongylidæ,* Sub-family *Strongylinæ,* and *Trichostrongylinæ;* Genera, *Bunostomum, Hæmonchus, Trichostrongylus, Ostertagi, Cooperia;* Species, *Bonostomum phlebotomun, Hæmonchus contortus, Hæmonchus* *similis, Ostertagi ostertagi, Cooperia pectinata, Cooperia punctata,* and *Trichostrongylus extenuatus.*

This will give some idea of the parasitic flora in the State, or at least as found in the stomachs of cattle slaughtered at the local abattoir.

In addition, ascarids were found on two occasions.

While no specific data are available at the present time, the writer feels safe in estimating that from 75 per cent to 80 per cent of all calves slaughtered at the abattoir harbor stomach worms. However, an effort will be made to obtain exact data on this particular point.

The damage done by these parasites is comparable to that accomplished by the hookworm in the human being, and the problems involved are also comparable. Sufficient has been written at various times, at different experiment stations, and by different authors, concerning the seriousness of this particular parasite.

It may be well at this time, however, to call attention to the fact, that in spite of all that has been said and written, the economic importance of animal parasites to the livestock interests of the South does not, as yet, seem to be fully realized.

''Diseases due to bacteria and filtrable viruses may be said to be spectacular, and demand immediate attention. The ravages of hog-cholera, causing speedy death throughout a herd of swine, are not likely to be overlooked. Anthrax, blackleg, foot and mouth disease, and other fatal diseases, have a sudden onset, and take prompt toll from which the stockman seeks immediate relief. That the causative organisms cannot be seen, only serves to place them in the category of the mysterious.

''On the other hand, animal parasites are not spectacular in their effects. They take their largest toll among young animals, and the loss is credited, by the stockman, and generally to his own satisfaction, to other causes. The young animal has no long previous record of established vitality and strength to make the owner inquire closely as to why his animal should die.

''The loss is attributed to loss of vitality, inherent weakness, or some other plausible cause. There is no warning rise of temperature, and there are few sudden deaths. The lack of febrile conditions inclines one to think that the animal is not sick, but merely unthrifty. The lack of thrift and the loss of condition may extend over long periods, and establish the idea that the animal in question is a weakling. When it finally succumbs to the long siege by the parasites present, no explanation of the death appears necessary. The animal 'never did well,' and the loss is discounted in advance. The parasites themselves are so common, that they, too, are discounted. It is often noticed, and the idea is established, that all animals have them—perfectly healthy normal animals, as well as the unthrifty.

''This has been the prevailing idea. We are beginning to understand the situation better, and to realize what animal parasites do; what unthriftiness means; and what parasitism costs in terms of diminished meat and milk production, poorer quality of meat, decreased horse power, increased susceptibility to bacterial and constitutional diseases and premature death.''—Hall, M. C., Vet. Med. March, 1922.

Smith, in his Manual of Veterinary Hygiene, has the following to say concerning animal parasites:

''The subject of parasitic attacks on the lower animals, especially the herbivora, is of extreme importance. Losses from this cause are very heavy, and in some years a veritable plague. The ravages of stomach and intestinal parasites have received insufficient attention.

''Heavy losses result from these, yet neither prevention nor treatment has received the consideration it deserves, and the same applies to most parasitic diseases. The life histories of the parasites prevent them from being directly contagious, and the necessity for an intermediate host gives a false sense of security; but it may at once be said that sheep with fluke, cattle with stomach worms, and horses with intestinal strongyles, are a great risk of infection on pasture lands. The anthrax animal is only dangerous when its blood is shed or its carcass left exposed, but every evacuation from the above parasitic patients may be a source of future trouble; and in the same way, every cough from a calf or sheep with 'husk,' (lung worms) scatters the ova of the parasite broadcast.''

The stomach worm has been considered, hitherto, mainly in connection with the sheep industry, and is quite a serious barrier to the success of that industry in Louisiana; nevertheless this parasite also attacks cattle, and is becoming a serious menace to cattle raising in this State. Calves show unthriftiness, are stunted in their growth, become anemic (bloodless), and there are occasional deaths. The losses are not so spectacular, as before stated, but they are none the less real.

The *Ostertagi ostertagi,* or stomach nodular worm, while not nearly so numerous, is nevertheless, a serious pest.

Ackert and Muldoon, at Kansas, have reported a case where, out of a herd of eighty-four steers, one-half became visibly affected, and 9 died, due to an infestation with this stomach nodular worm.

The worm is almost constantly found in calves. Many stomachs show erosions, especially in the pyloric region, due to superficial sloughing of the nodule after the passage of the parasite into the alimentary tract.

The cattle hookworm, *Bunostomum phlebotomum,* needs no introduction. Many names have been given to the condition caused by this parasite, such as salt sickness, uncinariasis, etc.

These worms belong to the same family as the hookworm of man, dog, cat, etc., and their effect upon the system is too well known to require further comment. But while the usual habitat of this worm is the small intestine, it invades the stomach in small numbers, and attaches itself to its walls, generally in the pyloric region.

The small nematode, *Trichostrongylus extenuatus,* has been accused of causing gastro-enteritis in calves. While but few specimens were found, it is entirely possible that the method of washing and examining the material may have been responsible for this.

The findings submitted in this report tend to confirm the opinion already generally held, that young animals suffer most from parasitism. This report further brings out the fact that large numbers of animals are affected. This being the case under present conditions, where our cattle have a more or less wide range of territory to roam over; what the condition may be when the animals are more confined to fenced areas, it is not difficult to imagine.

But while it is true that the losses are largely confined to young animals, it does not mean that mature animals are immune to infestation. This was well illustrated a few years ago when, during a period of severe drought, large numbers of Texas cattle were shipped into Louisiana for grazing purposes. Many of these animals, although mature, succumbed to the ravages of stomach worm infestation, due no doubt to their being poor and emaciated, and, therefore, unable to withstand the attacks of the disease.

The treatment for stomach worm disease has received considerable attention, and may be found in publications of this and other Experiment Stations, so that that need not be specially alluded to in this report. It may be said, however, that the Oklahoma Station recommends the addition of a one per cent tobacco infusion to the copper sulphate solution mentioned in Circular No. 31, of the Extension Division of this institution; and they claim 90 per cent to 100 per cent efficiency for this treatment.

In a recent letter from the Federal Bureau of Animal Industry, Dr. Hall recommends carbon tetrachloride ($C\,Cl_4$) claiming remarkable efficiency for the drug, not only for stomach worms, *Hæmonchus contortus,* but also for the smaller strongyles, such as *Ostertagi ostertagi, Cooperia,* and others.

Although the life history of the stomach worm, and its treatment, is known, there are one or two points on which more definite information is desired. The first of these is its longevity on pastures; and the second, the effect of feeding on stomach worm disease. Both of these are of extreme economic importance. The first, in its relation to the use and rotation of pastures; and the second, in its relation to the general prophylaxis against the disease.

On October 30, 1921, the second part of the work, viz., the examination of the small intestine for parasites, was commenced, and the method of procedure was similar to that adopted in the examination of the stomach contents.

In the beginning, the first few feet of the small intestine were opened, and the remainder of the intestinal tract everted in a manner similar to that used in making sausage casings.

Only a few trials, however, were sufficient to prove that this method had no advantage over the ordinary stripping of the intestinal contents into a bucket, or other suitable vessel, and it was abandoned.

The examination of a dozen or more animals was sufficient to convince the writer that the cattle hook worm is not generally found beyond the first four feet of the small intestine, and, therefore, it became a routine practice to cut off this portion and split it along its entire length for examination. The contents of the remainder of the small intestine were then washed into a bucket provided for the purpose.

A total of 170 calves were examined, and a close record kept of hookworm infestation for 142 calves, with the result that 113 of these, or 80 per cent, were found to harbor the cattle hookworm.

The remainder of the material collected consisted of the following genera and species:

Genus	*Cooperia*
Species	*Cooperia pectinata*
	Cooperia punctata
	Cooperia curticei
	Cooperia oncophora
Genus	*Trichostrongylus*
Species	*Trichostrongylus instabilis* (provisionally determined)
Genus	*Strongyloides*
Species	*Strongyloides papillosus* (provisionally determined)
Genus	*Bunostomum*
Species	*Bunostomum phlebotomum*
Genus	*Capillaria*
Species	Undetermined.

In addition to these a large amount of tapeworm material was collected; and ascarids were found on seven occasions.

In connection with these findings, the following points are of interest: The nematode, *Cooperia pectinata*, had, hitherto, been reported only once in the United States, and its regular and frequent occurrence here is, therefore, of interest.

Cooperia punctata and *Cooperia oncophora* have both been reported as parasites of cattle in this country, but the presence of *Cooperia curticei* in cattle establishes an apparently new record.

Some of these parasites, however, seem to differ somewhat from the published descriptions, and a further detailed study of them will be necessary.

The finding of *Trichostrongylus instabilis*, *Strongyloides* *papillosus,* and of the specimens of *Capillaria,* also, seems to be new, but it will require further study to establish their identity definitely.

The most significant fact brought out was the large percentage of infestation with cattle hookworm.

As previously mentioned, this nematode has been reported by various authors, and from various sources, as a most destructive parasite of cattle. It belongs to a family, all the members of which, found in different animals, including man, are destructive, and of the greatest economic importance.

As a matter of comparison, the intestinal tracts of about 30 beeves, or mature animals, were examined for hookworms but with negative results, which compare favorably with those obtained in the examination of the stomachs of mature cattle, tending to confirm our previous conclusions, that mature animals suffer very little, if at all, from parasitism.

Another interesting point observed, was that calves, which some time previous to slaughter had been ''lot-fed'', showed very little parasitic infestation, although many of them gave evidences of previous infestation. This point was illustrated by the results of the examination of calves during three consecutive months (February, March and April). The animals examined on those dates all showed evidence of better feeding and breeding; and the parasites recovered from them were few in number.

During the course of the year, the alimentary tracts of a few sheep were examined for parasites, and the general observations made with regard to cattle were found to hold true in their case. All of the lambs examined harbored both stomach and hook worms; and the smaller nematodes were also well represented. *Cooperia pectinata* and *Cooperia punctata* were found in the sheep. These parasites had not been, hitherto, reported for sheep, so that their finding establishes a new record.

The hookworm is not confined to the duodenum, as is generally the case in cattle, and the intestine must, therefore, be examined at greater length. The material collected has not yet been subjected to a detailed examination.

On other occasions, the livers of cattle have been examined for ''liver flukes.'' The species of these parasites have been recorded, viz., *Fasciola hepatica* and *Fasciola magna.* The former is usually found in the bile ducts, which are greatly enlarged and thickened; whereas the specimens of the latter were found embedded in the substance of the liver.

Both of these parasites and the conditions for which they are responsible, have been described in B. A. I. Bulletin No. 19, which may be consulted on these points.

The published report in the aforementioned bulletin, and an article entitled, ''Some Notes on Liver Fluke Disease as observed in Northern Rhodesia,'' by H. H. Hornsby, M. R. C. V. S., (Vet. Journ. No. 551, Vol. 77, No. 5.) show definitely that these parasites may be responsible for serious losses in cattle. They, therefore, deserve earnest consideration on the part of those who are interested in the livestock problems of the State.

The life history of the *Fasciola magna,* while presumably similar to that of the *Fasciola hepatica,* is unknown at the present time. The life history of this parasite, its pathology, and the extent of its invasion, are points about which more definite information is desirable.

Lung worms form another problem which should receive consideration at the hands of the parasitologist and pathologist.

Hog lungs have been examined at different times during the year. On one occasion the writer had the opportunity to examine 12 pairs of lungs for these parasites, nine of which were infested with lung worms—a 75 per cent infestation.

The conditions brought about by these parasites are too well known to require a detailed description in this report.

The examination of the posterior part of the alimentary canal of cattle, including the cecum and colon, has been commenced, but so far only a few animals have been examined. The parasites recovered, however, comprise the *Oesophagostomum radiatum* and the *Trichuris ovis.* Several animals were found to be heavily infested with these parasites; and the inflamed and thickened areas found in the ceca are indications of the injurious nature of the invaders.

In this connection it may be of interest to call attention to an article, in the June, 1922, issue of the North American Veterinarian, entitled ''Scours in Young Cattle,'' by Dr. M. Jacob, of the University of Tennessee. The author describes a serious condition of young cattle found in Tennessee, and names the *Oesophogostomum radiatum* as the cause of the trouble.

A short time ago, the Louisiana Station was visited by Mr. R. Owen Wahl, of the School of Agriculture, at Grootfontein, Union of South Africa. Mr. Wahl stated that this parasite, the nodule worm, caused tremendous losses in sheep in that country.

While it is true that there are several important points about this parasite that still remain to be studied, the work already done, and the observations made by different authors at various places, show that the parasite and its control are of great economic importance.

The results of the work, so far, may be summarized as follows:

The findings of Ransom, published in B. A. I. Bulletin No. 127, have been confirmed, with the following additions:

Hæmonchus similis, a new stomach worm of cattle discovered and described by Dr. Lauro Travassos, in Brazil, has been found in Louisiana cattle.

Cooperia pectinata, reported as a parasite of cattle, has been found in sheep.

Cooperia punctata, reported as a parasite of cattle, has been found in sheep—Two new records.

Cooperia curticei, reported as a parasite of sheep, has been found in cattle—A new record.

One species of *Trichostrongylus* and one of *Strongyloides,* not previously reported from cattle in the United States, have apparently been found as parasites of cattle during this investigation. These last two, however, will require more detailed study for confirmation.

In addition, Extension Circular No. 60, entitled "Hog Parasites," has been prepared and published in collaboration with M. M. LaCroix, Assistant in Swine Work; and a second publication, entitled "Diseases of Hogs," has also been prepared.

In conclusion, the writer desires to express his sincere appreciation to Dr. W. H. Dalrymple, Veterinarian and former Director, for his valuable aid and encouragement during the entire period of the work.

To Dr. Harry Morris, bacteriologist, for many valuable suggestions and hearty cooperation.

To Dr. J. I. Martin, Inspector and Manager at the Baton Rouge Municipal abattoir, for his unfailing courtesy, and assistance in the collection of the material, which greatly facilitated the work of the investigation.

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W. R. DODSON, DEAN AND DIRECTOR.

BATON ROUGE, LOUISIANA

"HOGGING DOWN CROPS"

COST OF PRODUCING CROPS AND PORK

BY

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"HOGGING DOWN" CROPS

COST OF PRODUCING CROPS AND PORK

SUMMARY

Soy beans, grown alone, was the cheapest crop to produce.

Corn and soy beans and corn and cowpeas were practically the same in cost of production.

Thirteen and one-half days of man labor and four days of horse labor, ten hours per day, were required to grow an acre of sweet potatoes.

In 1921, fifty-two pigs weighed 149.6 pounds at farrowing and 1480 pounds when weaned, approximately seven weeks old. During this time the sows and pigs consumed 2613 pounds of concentrates and 2320 pounds of skim milk and buttermilk. Sixty pigs, in 1922, weighed 170.7 pounds at farrowing and 1590 pounds at weaning. The pigs and sows consumed 2840 pounds of concentrated feed during the suckling period of about seven weeks. Good oat pasture was available at the time during the suckling period.

The fifty-two pigs ate 13,110 pounds of concentrates and 16,000 pounds of milk from weaning to "hogging down" in 1921. The gain during this time was 5020 pounds. It required 2.61 pounds of concentrates and 3.19 pounds of milk to make a pound of gain. In 1922, skim milk or butter milk was not available; 18,515 pounds of concentrates was consumed and the pigs gained 4165 pounds, or 4.44 pounds of feed was required for each pound of gain. In 1921, the pigs were fed all they would eat while the next year they were not fed nearly so heavily. The cheaper gain was made with the heavier feeding; calculating 5 pounds of milk to be equivalent to one pound of concentrates, 3.25 pounds of feed gave one pound of gain, while in 1922, with no milk and with light feeding, 4.44 pounds of feed gave a pound of gain. For the entire period from farrowing to the beginning of the "hogging down," in 1921, 3.05 pounds of grain (milk being reduced in terms of above) gave one pound of gain and in 1922, 3.82 pounds of grain gave one pound of gain.

Corn and soy beans gave the cheapest gains when "hogged down" in comparison with corn and cowpeas, corn, soy beans and sweet potatoes, sweet potatoes and soy beans and sweet potatoes alone. With corn and soy beans, the cost of producing 100 pounds of feed amounted to 2.9 man hours and 4.6 horse hours and the cost of producing 100 pounds of pork was 13.6 man hours and 21.6 horse hours. The corn and the soy beans should be planted at the same time, using two planters in order to plant the corn slightly deeper than the beans. The beans will produce a larger yield when planted early and the shade from the corn will not affect the beans to much extent.

Cowpeas produced seed only once in the four-year period. Soy beans should be substituted for cowpeas in south Louisiana.

Sweet potatoes set out after oats, or about the first to the middle of july, made a small yield per acre. The oats were grazed until nearly ready to cut for grain and the ground was usually hard and dry, making it rather difficult to prepare a good seedbed. Sweet potatoes should be set out during the first part of May, if the highest yield is expected. Sweet potatoes were "hogged down" at a loss, when not in a combination. Corn and soy beans and sweet potatoes make a very good combination.

"Hogging Down" Crops
Cost of Producing Crops and Pork

A. F. KIDDER and W. H. DALRYMPLE

Success in farming as in any other business should be measured in terms of profit. The ability to reduce cost of production without impairing a farm or discouraging labor is an important asset and is one of the main factors which help to make a profit in farming. The man and horse labor necessary in crop production is the large item of expense and all operations should be planned with this labor charge in mind.

The data herewith presented comprise a series of cost production studies begun in 1920. The labor cost of producing "hogging down" crops, the feed cost of growing hogs from farrowing to "hogging down", for 1921 and 1922 and the labor cost of pork produced by grazing the crops are included in this report. The crops grown were corn, corn and cowpeas, corn and soy beans, sweet potatoes and soy beans. Oats was seeded to all plats every fall but no labor cost record was kept. This was used for pasture for brood sows before farrowing as well as during the suckling period (approximately seven weeks). It is known that the labor cost of producing oats is less than for any of the other crops grown in this study. The oat crop was cut for grain from all plats, except one, in 1921 and 1922. The crop was cut on all plats in 1920. The average yield of oats on the grazed plats in 1920 and 1921 was nearly 15 bushels per acre and the grain was of good quality. In 1922, the yield from the

Acknowledgment is made to Prof. E. L. Jordan for assistance throughout the experiment and to E. A. Maier and E. K. Breeden for helping to keep the records.

grazed plats was four bushels per acre, low yield being due principally to adverse weather conditions. On good land, the yield of the oat crop after grazing, as under the conditions in this report, should be more than sufficient to pay the labor cost of production. The value of the grazing ought to be large enough to pay all other costs.

LABOR COST OF CROPS

The labor necessary for the production of the "hogging down" crops will be expressed in man hours and horse hours. The variable conditions as to price of labor and feed for horses makes it practically impossible to state these items in terms of dollars and cents. Anyone can readily estimate the cost in money to suit his conditions. Table 1 gives this labor cost.

TABLE I

LABOR COST OF "HOGGING DOWN" CROPS

Year	Plat	Area (acres)	CROP	HOURS	
				Man	Horse
1920	1c	2	Sweet Potatoes	260	80
1920	2c	2	Corn and Cowpeas	75	120
1920	3c	2	Corn	64	116
1920	4c	2.5	½A Sweet Potatoes	66	25
			2A Soy Beans	46	78
1921	1d	1	Sweet Potatoes	125	35
1921	2d	1.1	Soy Beans	25	40
1921	3d	1.1	Corn and Cowpeas	34	60
1921	1c	2	Soy Beans	54	72
1921	2c	2	Sweet Potatoes	256	78
1921	3c	2	Corn and Soy Beans	70	128
1921	4c	2.5	½A Sweet Potatoes	65	19
			2A Corn and Soy Beans	78	124
1922	1d	1	Soy Beans	29	35
1922	2d	1.1	Corn and Cowpeas	38	68
1922	3d	1.1	Sweet Potatoes	154	50
1922	1c	2	Corn and Soy Beans	80	134
1922	2c	2	Soy Beans	49	75
1922	3c	2	Sweet Potatoes	290	84
1922	4c	2.5	½A Soy Beans	18	24
			2A Corn and Soy Beans	91	98

The labor cost data in Table I cover a period of three years. The average number of man hours and horse hours per acre will be shown in Table II.

TABLE II

LABOR COST PER ACRE OF PRODUCING "HOGGING DOWN" CROPS

CROP	AVERAGE YEARS	HOURS	
		Man	Horse
Corn	1	32	58
Corn and Soy Beans	2	38.9	60.5
Corn and Cowpeas	3	35	59
Soy Beans	3	25.7	37.6
Sweet Potatoes	3	133.6	40.7

These crops were grown in small plats, the largest being two acres. The labor cost can be reduced considerably under farm conditions where larger areas may be used. Short rows should be eliminated wherever possible for a large amount of time is lost in turning at ends. The horse hours for corn alone in one year only is approximately the same as for corn and cowpeas or for corn and soy beans; an average of several years would probably reduce this figure.

FEED COST OF HOG PRODUCTION

The main factor in economical hog production is the feed cost. In 1921, when considering further work in cost of producing "hogging down" crops, it was thought well to include the cost of producing the hogs from farrowing to the time when they could be allowed to begin fattening by grazing off the crops grown for this purpose. These data include feed only, as the labor is almost a negligible factor. It would have been better if the time had begun with the service instead of at farrowing. The cost of concentrates during the pregnancy period was decreased by having good oat pasture. Further, it was noticed that nearly all of the pigs were strong and healthy at farrowing time, a condition that may be attributed to a good oat pasture.

Table III contains the farrowing record for 1921.

TABLE III

FARROWING RECORD, 1921

Sow	Date of Farrowing	No. of Pigs Farrowed	No. of Pigs at Weaning	Av'ge W'ght per Pig at Farrowing, Pounds	Av'ge W'ght per Pig at Weaning, Pounds
1	2/12/21	13	10	2.55	23.70
2	2/13/21	13	9	2.73	
3	3/10/21	11	10	3.30	30.00
4	3/13/21	10	8	3.12	
5	3/30/21	9	8	2.75	32.66
6	4/12/21	9	7	2.80	

The average weight of the pigs for each sow at farrowing includes only those pigs that were alive at weaning, an average of seven weeks old. As soon as possible after farrowing two sows were put together and the average weight at weaning includes two litters in all cases. Fifty-two pigs were saved out of a total of sixty-five farrowed from six sows or an average of 8⅔ per sow. These fifty-two pigs weighed 149.6 pounds when farrowed and 1480 pounds when weaned, thus making a gain of 1330.4 pounds during the suckling period. Table IV gives the kind and amount of feed consumed by sows and pigs during this period.

TABLE IV

FEED CONSUMED BY SOWS AND PIGS FROM FARROWING TO WEANING, 1921

KIND OF FEED	WEIGHT, LBS.
Wheat Bran	93
Wheat Shorts	40
Shelled Corn	256
Unbolted Corn Meal	59
Corn Chops	876
Rice Bran	40
Rice Polish	956
Tankage	188
Shrimp Bran	105
Skim Milk and Buttermilk	2320

In addition to the feed given in Table IV, the sows and pigs had access to good oat pasture. The total amount of concentrates consumed during the suckling period in 1921 was 2613 pounds and 2320 pounds of skim milk and buttermilk was fed in addition. It was noticed that both sows and pigs ate more after milk was added to the ration.

The farrowing record for 1921 is in Table V.

TABLE V

FARROWING RECORD, 1922

Sow	Date of Farrowing	No. of Pigs Farrowed	No. of Pigs at Weaning	A'vge W'ght per Pig at Farrowing, Pounds	Av'ge W'ght per Pig at Weaning, Pounds
1	12/31/21	7	4*	2.00	33.00
2	1/8/22	9	7*	2.14	
3	2/18/22	6	6	2.50	26.00
4	2/23/22	7	7	2.90	
5	3/1/22	4	4	2.25	24.00
6	3/1/22	6	6	2.10	
7	3/2/22	9	7	2.10	
8	3/6/22	11	11	3.47	24.20
9	3/7/22	7	6	3.00	
10	3/9/22	7	7	2.85	

*Ten weeks old when weaned.

The average weight at farrowing represents as in 1921 only the weight of pigs alive at weaning. The pigs from sow 8 while large at birth did not seem to grow off as quickly as some of the smaller ones. However, all appeared healthy and no attempt was made to force them more than the others. Sixty-five were saved out of a total of seventy-three or an average of 6½ pigs per sow against 8⅔ in 1921. This was probably due to the fact that seven of the sows in 1922 were gilts of a small-bone type. They were purchased late in December, 1921. Sow 4 was a big-bone Poland-China and sows 8 and 9 were grades that have been on the Station for several years. These ten sows and pigs consumed 2840 pounds of concentrated feed in addition to good oat pasture from farrowing to weaning. A detailed statement of feeds is given in Table VI.

TABLE VI

FEED CONSUMED BY SOWS AND PIGS FROM FARROWING TO WEANING, 1922

KIND OF FEED	WEIGHT, LBS.
Wheat Bran	118
Wheat Shorts	17
Crushed Soy Beans	15
Corn Chops	2280
Tankage	410

The sixty-five pigs weighed 170.7 pounds at birth and 1590 pounds when weaned, thus making a gain of 1419.3 pounds during the suckling period.

During the two years, all the pigs were put together as soon as weaned and the amount of feed weighed each time they were fed. They were fed three times a day when first weaned, changing to twice (morning and evening) about one month later. Table VII gives the kind and amount of feed consumed by the pigs from weaning to the beginning of the "hogging down" period.

TABLE VII

FEED CONSUMED BY PIGS FROM WEANING TO "HOGGING DOWN"

KIND OF FEED	WEIGHT 1921	POUNDS 1922
Wheat Shorts	2915	——
Corn Chops	660	4000
Unbolted Corn Meal	——	6400
Ear Corn	——	2400
Rice Polish	6580	——
Rice Bran	2930	1800
Whole Oats	——	1000
Cane Molasses (Black Strap)	——	400
Tankage	20	2515
Shrimp Bran	5	——
Skim Milk and Buttermilk	16000	——

In 1921, 52 pigs consumed 13,110 pounds of concentrates and 16,000 pounds of skim milk and buttermilk. The weight at time of weaning was 1480 pounds and the weight when hand feeding ceased was 6500 pounds, the gain being 5020 pounds. The amount of feed required to make a pound of gain was 2.61 pounds of concentrates and 3.19 pounds of milk. During the feeding period of 1922, skim milk and buttermilk were not available. The 65 pigs for that year consumed 18,515 pounds of concentrates or 4.44 pounds for each pound of gain, the weight at weaning being 1590 pounds and at end of the feeding period being 5755 pounds or a gain of 4165 pounds.

It is fair to charge the total amount of feed consumed by the sows and pigs during the suckling period and by the pigs from weaning to "hogging down" to the gain in weight of the pigs. Table VIII gives the total feed and the total gain for the two periods. Initial weight of pigs at farrowing has been deducted.

TABLE VIII

TOTAL FEED CONSUMED AND GAIN FROM FARROWING TO "HOGGING DOWN"

KIND OF FEED	WEIGHT OF FEED, LBS		GAIN, LBS.	
	1921	1922	1921	1922
Concentrates	15723	21355		
			6350.4	5584.3
Skim Milk and Buttermilk	18320	——		

A study of the data in Table VIII reveals that 3.05 and 3.82 pounds of grain was necessary to produce a pound of pork for the above period in 1921 and 1922, respectively. The skim milk and buttermilk were calculated on the basis of 5 pounds of the milk being equivalent to 1 pound of grain. In 1921, the pigs averaged 2.88 pounds at birth and 125 pounds when hand feeding stopped; the weights for 1922 were 2.62 and 88.5 pounds respectively. The pigs were fed liberally in 1921, being given practically all they would eat every day while, in 1922, the daily feeding was not nearly so heavy. The cheaper gain was with the heavy feeding.

RESULTS OF "HOGGING DOWN" CROPS

These data cover a period of four years. The results for each year will be given separately. In 1919, 2 acres of corn and cowpeas, 4.25 acres of corn and soy beans (planted in alternate rows five feet wide), 2.75 acres of sweet potatoes, 2 acres of soy beans and 2 acres of sweet potatoes were harvested by means of hogs. No labor costs were kept in 1919. The data will be found in Table IX.

The 2.75 acres of sweet potatoes and 4.25 acres of corn and soy beans were grown on very poor soil which accounts for the extremely low yields. The pork production from these low yields was considerably more satisfactory than if the crops had been harvested by hand and then sold.

In 1920, seven acres were harvested by hogs. This acreage included 2 of corn and cowpeas, 2 of corn, 1 of soy beans and 2 of sweet potatoes. See Table X for the data.

During the 16 days while the hogs were eating sweet potatoes, 192 pounds of shrimp bran were also consumed. The bran was put into a self-feeder and the hogs had access to it all the time.

The 26 hogs used on the corn and cowpeas included 18 pigs that averaged only 42 pounds while the other 8 weighed 131.5 pounds each. The same hogs were used in all the grazing for 1920. At the beginning, all of them were placed together in order to see if the small ones would remain in good growing condition. All were in good

TABLE IX
RESULTS OF "HOGGING DOWN" CROPS FOR 1919

CROP	Acres	Estimated Yield per Acre Bushels	Dates of Grazing		No. Days	No. Hogs	Weight of Hogs Pounds		Total Gain Pounds	Average Daily Gain Pounds	Pounds Feed Consumed per Pound Gain
			Begin	End			Begin	End			
Corn and Cowpeas	2	26.00 5.50	Sept. 16	Oct. 1	16	25	2600	3260	660	1.65	4.9
Sweet Potatoes Corn Soy Beans	2.75 2.125 2.125	56.4 4.75 2.50	OCT. 2	Nov. 6	36	35	4865	6290	1425	1.13	7.1
Sweet Potatoes Soy Beans	2.000 2.000	140* 10	Nov. 7	Dec. 7	31	35	6290	7910	1620	1.49	11.1

*670 pounds of corn fed in addition.

TABLE X
RESULTS OF "HOGGING DOWN" CROPS FOR 1920

CROP	Acres	Estimated Yield per Acre	Dates of Grazing		No. Days	No. Hogs	Weight of Hogs Pounds		Total Gain Pounds	Average Daily Gain Pounds	Pounds Feed Consumed per Pound Gain
			Begin	End			Begin	End			
Corn and Cowpeas	2	25.00 00.00*	Aug. 28	Oct. 5	39	26	1810	2340	530	.52	5.3
Corn Soy Bans	2 1	15.00 20.00	Oct. 6	Nov. 5	30	26	2340	3170	830	1.06	3.4
† Sweet Potatoes	2	75.00‡	Nov. 6	Nov. 21	16	26	3170	3595	425	1.02	21.4

* Considerable vine growth. All consumed by pigs.

† Followed an oat crop; grazed and later cut for grain.

‡ Fed 192 pounds of shrimp bran in addition.

condition after finishing the corn and cowpeas as well as the crops taken off later.

The crops grown for the grazing in 1921 were as follows; 1.1 acres of corn and cowpeas, 4 acres of corn and soy beans, 3.1 acres of soy beans and 3.5 acres of sweet potatoes. The soy beans were sown in the corn at the last cultivation.

During the first grazing period (August 21 to August 30, inclusive) the weather was very hot and the hogs had the run of a Bermuda grass pasture in addition in order that they might have plenty of shade and drinking water. They did not seem to eat the corn at first and it is probable that they were left a day too long on the plat to get the best results. The small gain of .23 of a pound per day per hog was attributed mainly to the extremely hot weather. When the transfer to the corn and soy beans and sweet potatoes was made, considerably cooler weather prevailed and the hogs ate much better. The gain during the second period was rather large, being 2.325 pounds per day per animal. The soy beans grazed with sweet potatoes made very few beans but the vegative growth was rank. The hogs ate the soy bean plants only fairly well, seeming to prefer the sweet potatoes and the sweet potato vines. The sweet potatoes and soy beans grazed from September 27 to October9 were more mature. This, together with cooler weather, may have been the cause of the larger gain than was made when the first sweet potatoes and soy beans were "hogged off."

The sixty-three pigs were divided into three lots, according to size. The ten turned into the corn and cowpeas were practically of the same weight, varying only a pound or so; the same was also true of the twenty turned into the 2.5 acres of corn and soy beans and soy beans; while the individual weights of the 33 turned into the 2 acres of soy beans varied slightly more. The time for harvesting the crops was considerably more than if all had been placed on each plat.

TABLE XI

RESULTS OF "HOGGING DOWN" CROPS FOR 1921

CROP	Acres	Estimated Yield per Acre Bushels	Dates of Grazing		No. Day	No. Hog	Weight of Hogs Pounds		Total Gain Pounds	Average Daily Gain Pounds	Pounds Feed Consumed per Pound Gain
			Begin	End			Begin	End			
Corn and Cowpeas	1.1	28.75 00.00*	Aug. 21	Aug. 30	10	52	6500	6620	120†	0.23	14.7
Corn and Soy Beans Sweet Potatoes	4.0 0.5	26.10 1.50 138.60	Aug. 31	Sept. 15	16	51	6535	8435	1900	2.3	5.9
‡Sweet Potatoes Soy Beans	1.0 1.1	70.00 5.00	Sept. 16	Sept. 26	11	51	8435	8820	385	0.68	11.7
‡Sweet Potatoes Soy Beans	2.0 2.0	60.00 5.00	Sept. 27	Oct. 9	13	40	6500	7450	950	1.8	8.2

* Considerable vine growth. All consumed by pigs.

† Extremely hot weather.

‡ Followed an oat crop: grazed and later cut for grain.

TABLE XII

RESULTS OF "HOGGING DOWN" CROPS FOR 1922

CROP	Acres	Estimated Yield per Acre Bushels	Dates of Grazing		No. Days	No. Hogs	Weight of Hogs Pounds		Total Gain Pounds	Average Daily Gain Pounds	Pounds Feed Consumed per Pound Gain
			Begin	End			Begin	End			
Corn and Cowpeas	1.1	30.80 00.00*	Aug. 22	Sept. 15	25	10	960	1340	380	1.5	5.0
Corn and Soy Beans	2.0	26.00 2.00	Aug. 30	Sept. 18	20	33	2315	2940	625	0.95	5.0
Corn and Soy Beans Soy Beans	2.0 0.5	21.00 2.00 12.00	Aug. 30	Sept. 12	14	20	2440	2900	460	1.6	6.4
†Sweet Potatoes Soy Beans	1.1 1.0	68.10‡ 10.00‡	Sept. 23	Oct. 2	8	63	7615	8315	700	1.4	7.3
†Sweet Potatoes Soy Beans	2.0 2.0	90.00§ 15.00§	Oct. 10	Oct. 23	14	40	4680	5690	1010	1.8	12.4

* Considerable vine growth. All consumed by pigs.

† Followed an oat crop: grazed and later cut for grain.

‡ Fed 10 pounds salt in addition.

§ Fed five pounds salt in addition.

TABLE XIII

LABOR COST OF "HOGGING DOWN" CROPS AND OF PORK PRODUCED

CROPS	Years Ave.	Feed per Acre Pounds	Pork per Acre Pounds	Labor Cost Hours per Acre		Labor Cost Hours per 100 Pounds Feed		Labor Cost Hours per 100 Pounds Pork		Pork Produced by 100 Lbs. Feed
				Man	Horse	Man	Horse	Man	Horse	
Corn and Cowpeas	4	1620	272.6	35.0	59.0	2.1	3.6	12.8	21.6	16.8
Corn and Soy Beans	2	1200	255.3	34.9	55.2	2.9	4.6	13.6	21.6	21.3
Corn Soy Beans Sweet Potatoes	2	1790*	289.1	62.2	50.2	3.4	2.8	21.5	17.3	16.1
Soy Beans Sweet Potatoes	3	2965	288.0	79.6	39.1	2.7	1.3	27.6	13.5	9.7
Sweet Potatoes	1	4500†	212.5	133.7	41.8	2.9	0.9	62.9	19.6	4.7

* 670 pounds corn fed extra in 1919.

† 192 pounds shrimp bran fed extra.

The labor cost of feed (grazing crops only) and the labor cost of the pork produced from the grazing crops will be found in Table XIII.

The labor cost of producing the corn and soy beans was less than that of any of the other crops. This was due to the fact that some of the beans grazed with the corn were grown alone. In all cases, where the two crops were grown together, the soy beans were not planted until the last cultivation of the corn. This is too late to plant soy beans for high yields as the shade from the corn seems to check the growth. It would be better to plant the beans and the corn at the same time, using either a duplex planter or two planters. The writers prefer using two planters in order to plant the corn slightly deeper than the beans. The labor necessary to produce soy beans is considerably less than for corn and it might pay better to grow the two crops separately and "hog them off" together.

Corn with cowpeas ranks second when labor cost is considered. Cowpeas produced seed only once in four years, and for this reason are not as good a companion crop for corn as soy beans. The cowpeas were sown at the last cultivation of the corn.

Corn, soy beans and sweet potatoes, as a "hogging down" combination, do not show as good results as corn with either cowpeas or soy beans. The large amount of hand labor required to set out sweet potato vines makes the labor cost of this crop considerably higher. In this case, 21.5 man hours and 17.3 horse hours were necessary to make 100 pounds of pork as against 13.6 man hours and and 21.6 horse hours for corn and soy beans, and 12.8 man hours and 21.6 horse hours for corn and cowpeas. The sweet potatoes were set out after oats, in most instances, which is the explanation of the small yield, particularly, when they were "hogged off" before fully mature. The sweet potato and soy bean combination proved only fair. Sweet potatoes alone, while tried only one year, showed a loss.

Experiments on the time to set out sweet potato plants or vines, previously conducted at the Station, show that the highest yields were obtained when the plants or vines were put out during the first two weeks in May. The soil is usually thoroughly warm by this time and the plants grow off rapidly. The oat crop cannot be harvested for grain and get the sweet potatoes out by this time, but one can make hay from the oats. Some of the oats may be grazed for the grain, and sweet potatoes, cowpeas, or soy beans may be used to follow. High yields should not be expected from any of these crops because the time of planting or setting out will be late.

The hogs grazing on sweet potatoes ate the vines as well as the potatoes. Samples of the vines were taken for analysis in 1920 and 1921. The results of these analyses will be given on the dry basis. The samples were taken from the end of the vines back three feet and divided into three parts; the first foot is the extreme tip of the vine, the second foot comes next, and the third foot is nearest the hill.

TABLE XIV

ANALYSIS OF SWEET POTATO VINES

SAMPLE	Crude Protein %	Fat %	Carbohydrates %	Crude Fiber %	Water %	Ash %
First Foot from Tip	14.84	3.07	50.60	14.97	5.37	11.12
Second Foot	13.25	3.32	49.60	17.08	4.86	11.87
Third Foot	10.72	3.42	48.85	18.30	5.15	13.37

The green vines contained about 85% of water. The crude protein and the carbohydrates decrease as the distance from the tip of the vine is increased, while the fat, the crude fiber and the ash increase.

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AGRICULTURAL EXPERIMENT STATIONS

W. R. DODSON, DEAN AND DIRECTOR

BATON ROUGE, LOUISIANA

THE SWEET POTATO WEEVIL IN LOUISIANA AND ITS CONTROL

BY

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IN COOPERATION WITH
AGRICULTURAL EXPERIMENT STATIONS OF
LOUISIANA STATE UNIVERSITY

THE SWEET-POTATO WEEVIL IN LOUISIANA AND ITS CONTROL

By CHAS. E. SMITH,

INTRODUCTION.

The sweet-potato weevil* has long been recognized as a very destructive insect enemy of the sweet potato. It has, however, received unusual attention in the United States during the past few years because of the fact that the growing of sweet potatoes has rapidly become of more importance, particularly in the cotton-growing States. This rapid development of the sweet potato industry has been due to various causes. Following the spread of the cotton-boll weevil across these States many farmers turned their attention to the sweet potato as a possible money crop. The demand for more food crops during the World War and the development of satisfactory methods of curing and handling the crop have also given an impetus to the growing of sweet potatoes. Under these conditions the production and value of the crop in Louisiana increased more than five times between 1915 and 1920 and the whole country experienced a great increase. The sweet potato, therefore, entered commerce as never before and, because the sweet-potato weevil may be carried in sweet potato plants and tubers, this serious insect pest was introduced into many new localities.

The seriousness of the sweet-potato weevil situation was revealed by a preliminary survey made in 1917 by various agricultural workers, especially county agents, located in regions where the pest was present. Through an appropriation made by Congress, an organized study of the insect was begun in the spring of 1918 by the Bureau of Entomology, United States Department of Agriculture, in co-operation with the agricultural forces of the several states in which the weevil occurred. This was done for the purpose of checking the spread of the pest and finding practical means for its control. The work in Louisiana was begun in April, 1918, and continued through June, 1920.

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* Cylas formicarius Fab.

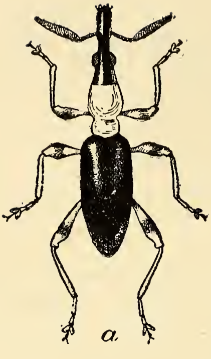

Fig. 1.—The sweet-potato weevil *Cylas formicarius* Fab.: a, male beetle; b, pupa; c, larva, dorsal view; d, larva, side view—all enlarged. (After Chittenden, U. S. Dept. of Agriculture.)

FOREIGN DISTRIBUTION.

The native home of the sweet-potato weevil is not known, but is thought to be in the Orient. A careful study of its distribution abroad has never been made but it has been reported from different parts of Asia and Africa and outlying islands of both continents; the list including India, Ceylon, Cochin China, Hongkong, Mauritius, Uganda Protectorate, Gold Coast of Africa, Friendly Islands, Liberia, Madagascar, Hawaii, Guam, Formosa, Philippine Islands, and practically all of the West Indies (Cuba, Porto Rico, Haiti, Grand Cayman and Jamaica). It has also been reported as a pest from Australia, from British Guiana, in South America, and from Java and Sumatra of the East Indies.

DISTRIBUTION IN THE UNITED STATES.

Before the Bureau of Entomology began its special investigations of the sweet-potato weevil in 1917, it had been recorded as occurring in three states only; namely, Louisiana, Texas, and Florida. However, Government agents soon determined that the insect had established itself in several localities in Southern Mississippi, Alabama, and Georgia. The weevil was found scattered throughout the eastern half of Texas, extending to and including several counties bordering on Oklohoma, in which it has more recently (1922) been reported to be present. With a few exceptions, it had made less progress inland in all the other infested states, confining its ravages for the most part to the coastal regions.

The first report of the occurrence of the sweet-potato weevil in the United States was made from New Orleans, Louisiana, in 1875. It was next reported from Manatee, Florida, in 1878, and from Galveston and Harris Counties, Texas, in 1890. The source of the first introduction is unknown.

DISTRIBUTION IN LOUISIANA.

The sweet-potato weevil had been unsuccessful, up to and including the time the preliminary survey was made in 1917, in permanently establishing itself in the upper two-thirds of Louisiana. More than six thousand properties were inspected during the survey (many of them were visited two or more times) and of these 736 were found to be infested. These infested properties were situated in 122 different localities (postoffice address) in 27 parishes. This does not include all the infested properties that existed in the State at the time because no farm-to-farm inspection was made in localities that were found to be generally infested. The territory that was found to be quite generally infested with the weevil consisted of Ascension, Assumption, Calcasieu (southern half), Iberia, Iberville (southern half), Jefferson, Lafayette, LaFourche, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptist, St. Martin, St. Mary, St. Tammany, Terrebonne and Vermilion Parishes. One infested property was found in each of the Parishes of Acadia (at Estherwood), Caddo (at Greenwood), East Baton Rouge (at Burtville), and St. Landry (at Bayou Current); on about half a dozen farms in Livingston (at Port Vincent), and on a like number in Tangipahoa (at Roberts and Ponchatoula) and West Baton Rouge (at Addis and Cinclare).

The introduction of the weevil into several new localities has come to the attention of the writer since the Government discontinued its work on the weevil in the State. The pest found its way to Stevensdale (East Baton Rouge Parish), supposedly in planting stock in the spring of 1921, and had spread to a number of farms in the surrounding community by the end of 1922. It was noticed by a grower in a community two miles west of Ponchatoula (Tangipahoa Parish) in the 1921 crop, and severe losses resulted to the 1922 crop. H. F. Cassell, County Agent of Tangipahoa Parish, reports that the weevil was introduced into a locality just north of Independence, and caused losses ranging up to 100 per cent of the 1922 crop. An introduction was made in 1921 at Blanchard (Caddo Parish), through slips received from Texas, and a loss of about 25 per cent of the crop resulted that year. No sweet potatoes were grown on the infested property in 1922, and W. E. Anderson, Entomologist of the Louisiana Department of Agriculture and Immigration, informed the writer that this infestation had apparently been stamped out. On April 2, 1923, the writer found one infested property at Denham Springs (Livingston Parish). The introduction was made by a tenant moving on the property in 1922 from Port Vincent (Livingston Parish) and bringing infested seed potatoes with him.

During the intensive survey of 1918-1920 the sweet-potato weevil was not found in several localities from which it had been previously reported, and where it doubtless had occurred. Among these were localities in Caddo and Bossier Parishes near Shreveport, Cheneyville (Rapides Parish), French Settlement (Livingston Parish), and several communities in Calcasieu and Jefferson Davis Parishes. The pest was reported to have been introduced at Shreveport and Cheneyville in 1915 in planting stock from the southern part of the State, when a number of cotton growers turned their attention to the sweet potato as a possible money crop because of the slump in cotton prices caused by the World War.

The disappearance of the sweet-potato weevil from these localities was probably due to several factors; the principal ones being the destruction of all infested potatoes, discontinuance of the crop, the use of clean planting stock and crop rotation, the absence of wild host plants, and possibly, weather conditions.

DESCRIPTIVE *.

The Adult: "The adult of the sweet-potato weevil is a snout-beetle of ant-like appearance, about one-fourth of an inch long, with metallic dark-blue elytra or wing covers. It is slender, cylindrical, with distended or 'swollen' body and long legs. The prominent head and beak are dark blue and the thorax or 'waist' is brick red, as are also the sides of the legs; and the

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* From "The Sweet-Potato Weevil and Its Control", by Dr. F. H. Chittenden. Farmers' Bulletin 1020, United States Department of Agriculture, 1919.

long antennae or 'feelers' are yellowish red. The antennae have long, thick clubs at the ends, and the male, which bears the longer clubs, can be distinguished from the female.

The Egg: "The egg is pale yellowish, broadly oval, somewhat narrowed at the attached end; the surface is not polished, but shows slight granulation and a faint appearance of division into facets. The length is about one-fortieth of an inch (0.65 mm.).

The Larva: "The larva, when grown, is cylindrical, robust, with the lateral edges of each segment prominent and rounded. The color is nearly pure white, the head pale brown, and the mouth parts dark brown. A few sparse, delicate hairs can be seen under the microscope. On the thoracic segments there are three pairs of broad leg-pads. The length is about three-eighths of an inch (9 mm.).

The Pupa: "The pupa is at first the same color as the larva, but grows darker just before transformation to adult. The wing pads are short and narrow and are folded over the lower side of the body. The head and beak fold down upon the breast. The last segment is furnished with two backward and outward curved tubercles. On the head are several minute tubercles, each of which bears a slender hair. It is about one-sixth inch (4 mm.) long, or the same as the beetle without the beak.

"The pupa is inactive, not partaking of food. The lower half of the body is mobile, enabling the pupa to turn about in its burrow or pupal case."

LIFE HISTORY AND HABITS.

The adult sweet-potato weevil never enters a true state of hibernation in Louisiana, though it becomes less active and egg laying ceases under low temperatures. Freshly laid eggs were found in leftover tubers in the field at Mandeville and Audubon Park, New Orleans, in January, 1919, at which time the weather was very mild. Eggs, larvae, pupae and adults can be found at any time of the year in the vicinity of New Orleans, especially, in protected sweet potatoes.

From 28 to 30 days are required for the development of the weevil from egg to adult in warm weather. The egg hatches in five or six days, the larva reaches maturity in about 15 days, and the pupal stage occupies a period of about eight days. About seven days elapse after the adult issues before egg laying begins. All these periods are lengthened with the lowering of the temperature.

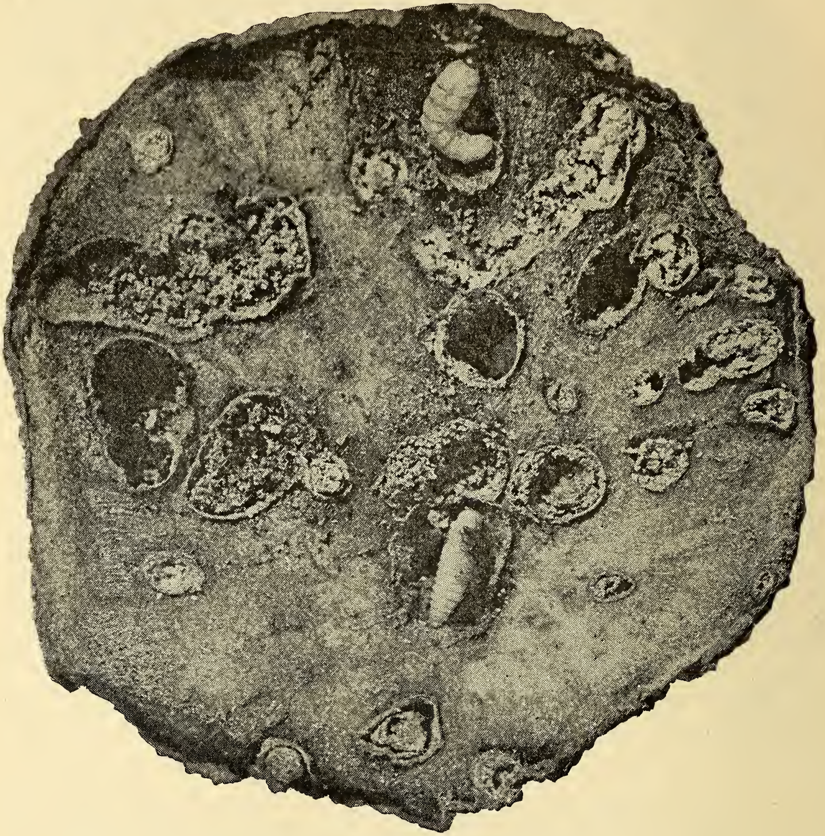

Fig. 2.—Cross section of sweet potato showing injury by sweet-potato weevil. Larva in burrow at top; pupa below; openings to tunnels elsewhere. Enlarged 3 diameters. (After Chittenden, U. S. Dept. of Agriculture.)

Several series of experiments were conducted at Audubon Park in 1919 to determine the length of life of adult weevils without food; when given access to weeds that are common in the field in early spring; and when given sweet potato for food. No evidence of the weevil feeding on any of the weeds was detected. Due to the scarcity of infested material at hand adults from all obtainable sources were used in the experiments, many of which were collected in the adult stage in the field. The first series was started on February 7, beetles that were collected in the adult stage being used. The maximum life of beetles kept without food was 72 days, and of those having access to weeds 51 days. Of the 10 given sweet potato as food, two did not die until April 15, one on June 21, and one lived until October 28, or a total of 264 days. This was a female and egg laying continued throughout the whole period. The body of the weevil became covered with the "chinch bug fungus" a few days after death, so this disease was possibly responsible for its death.

There are no clear cut generations of the sweet-potato weevil in Louisiana, partly or wholly due to the long period of oviposition, as is illustrated by the above mentioned female. On account of the almost continuous breeding in Southern Louisiana there are at least eight broods or generations produced during the year.

Sex determinations were made of a number of collections of adults made in connection with observations on the overwintering of the weevil and it was found that about ninety per cent of those found in early spring were females. Out of 88 individuals collected on one occasion, only five were males, and of another collection of 42 individuals only three. These two collections are representative of a number of others that were made in the vicinity of New Orleans in early spring.

The adult stage is directly responsible for but a small amount of the damage caused by the sweet-potato weevil, the larva being the most destructive stage. In feeding, the adults make small, shallow punctures in the stalks and tubers and eat irregular holes in the leaves. Eggs are not deposited in the perdendicular feeding punctures, but are placed in specially prepared cavities bored at an angle of about 60 degrees and having very small openings. The outer surface of the stalk or tuber directly over the egg cavity usually becomes slightly sunken, making a small concave spot adjacent to the opening, by which it can be distinguished from a feeding puncture. Upon hatching, the small white grub, or larva, begins to tunnel, or make "runs" through the stalk, or tuber. These are filled behind the larvae with excrement. Tubers badly infested have such a bitter taste that hogs and cattle will not eat them.

The first injury to a crop begins soon after slips are set in the field. Eggs are deposited in the crown, or stem, near the surface of the ground, and the grubs that issue from these eggs sometimes tunnel vines so severely as to kill them, or weaken them to such an extent that no roots are produced. After roots, or tubers, are formed, the female will enter the soil, usually through cracks caused by the developing roots or dry weather, and deposit eggs directly in them. The larvae from these eggs tunnel through the tuber, thus rendering it unfit for human consumption. This work may be continued throughout the growing season and also in the tubers placed in storage.

There are several insects that injure sweet potatoes in much the same way as the sweet-potato weevil. The "coffee-bean weevil" (*Araecerus fasciculatus* DeG.) is often found in sweet potato storage places. It has only been observed feeding and breeding on dry, decayed tubers. Wire worms often do considerable injury to sweet potatoes especially when grown on sod land. These click beetle larvae bore holes of considerable size and depth into the tubers before the crop is harvested and these holes might be mistaken for exit holes of emerging adult sweet-potato weevils. The injury caused by Diabrotica larvae is probably more often wrongly diagnosed than any other insect damage to sweet potato. This injury resembles the feeding punctures of the adult weevil, though it is usually considerably deeper. The larva of the "belted cucumber beetle" (*Diabrotica balteata* Lec.) is the only species of Diabrotica definitely known to injure sweet potato tubers.

WILD HOST PLANTS.

The sweet-potato weevil was found feeding on and breeding only in plants belonging to the morning-glory family—to which the sweet potato belongs—during the investigations in Louisiana. Eleven wild morning-glories and tie-vines were found growing in that part of the State infested with the weevil. Larvae were found infesting eight of these; namely, *Ipomoea pandurata, I. pes-caprae, I. trichocarpa, I. triloba, I. lacunosa, Pharbitis hederacea, P. barbigera,* and *Jacquemontia tamnifolia.* The last three named tie-vines were each found infested with larvae once only, and in each case the plants were growing in the midst of very severe infestations of the weevil. These tie-vines grow promiscuously over the infested part of the State, and were found uninfested many times when growing close to other infested plants. The other three tie-vines collected in which no weevil larvae were found were *Ipomoea littoralis, I. speciosa* and *Convolvulus repens. Ipomoea littoralis* was found growing on the sandy beach of Grand Isle only, and four or five hundred yards from the closest weevil infestation. This infestation was supposed to have been introduced the spring before in seed potatoes. The other two uninfested species were collected in several infested localities, but not in the very midst of other infested plants.

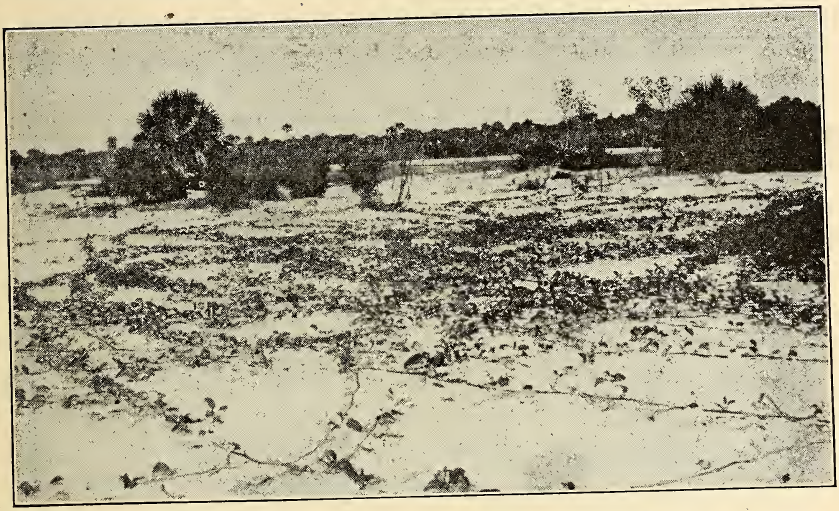

Fig. 3.—View of beach, showing characteristic spreading growth of the beach morning-glory, *Ipomoea pes-caprae*, a wild food plant of the sweet-potato weevil. (After Chittenden, U. S. Dept. of Agriculture.)

The "seaside morning-glory", (*Ipomoea pes-caprae*), was found growing only on the sandy beaches of Grand Isle and Cow Island (a small island located off the coast of Terrebonne Parish) and was infested only on the latter island. Land on Cow Island was cultivated at one time and sweet potatoes raised, but no farming was done on the island for 12 years just previous to the time the infestation was noted.

The large-rooted perennial morning-glory, (*Ipomoea pandurata*), was noticeably the preferred wild host plant of the weevil on the mainland and is liked equally as well, if not preferred, to the sweet potato itself. This plant was found growing on practically all types of soils in Southern Louisiana, which included the red hills of Avery Island, the stiff black soils, as those in the vicinity of New Iberia, the bluff soils at Baton Rouge, and along the ravines that drain the pine woodlands of Livingston and St. Tammany Parishes.

Inland, *Ipomoea trichocarpa* ranked next to *I. pandurata* as a wild host of the weevil. While it is listed as an annual, the roots of this plant were found to be very heavily infested with the larval, pupal and adult stages of the weevil at Audubon Park, New Orleans, on January 15, 1919. This plant is seldom found in cultivated fields, but is one of the most common weeds of the ditch banks, hedges, and fence rows throughout South Louisiana.

Those parts of the wild host plants in the proximity of the surface of the soil are most commonly infested by the sweet-potato weevil. Larvae are seldom found more than one or two inches below the surface of the soil. They were never taken in the "seaside morning-glory" vines when covered by more than one inch of sand. After the season was well advanced larvae were common in vines of *Ipomoea pandurata* growing on hedges on Avery Island, some being found ten or twelve feet above the ground. On but one occasion were larvae found mining the large tuberous root of *pandurata* when green, but they worked freely in those that had been dug and allowed to dry for a while. A number of plants of this species were found dead on Avery Island, having been practically severed just above the ground by the larvae.

DISSEMINATION.

Commerce is largely responsible for the spread of the sweet-potato weevil. The transference of infested seed potatoes is the most common medium of introduction of the pest, but a number of conspicuous infestations noted in Louisiana originated from slips shipped in from infested territory. The introduction of new varieties of sweet potatoes into South Louisiana has contributed indirectly to the spread of the pest. The variety known as the "Porto Rico" was responsible for the rapid spread in some communities.

The sweet-potato weevil has well developed wings, but seldom uses them for flight. During the course of the survey, inspectors observed three adult beetles in the field spread their wings, but none of them took flight. On a hot sultry day at Audubon Park, several beetles were noted flying across from side to side in a glass jar which measured about 10 inches in diameter, but not one flew away when offered its liberty.

Rains, winds and overflowing streams have had little or no effect on the dispersion of the sweet-potato weevil in Louisiana. Since practically all streams in South Louisiana rise in uninfested territory and pass through infested territory, this would tend to check rather than assist the natural spread.

Observations indicate that the sweet-potato weevil will not travel very far unaided; that is, that the natural spread is very slow. This is especially true when plenty of food is at hand. The "seaside morning-glory", which is known to be very much liked by the weevil, was found growing uninfested within about four hundred yards of an infested sweet potato patch on Grand Isle. This observation was made on September 18, 1918, and the infestation was supposed to have been carried to the Island the spring before.

In the spring of 1920 sweet potato tubers were placed as traps at different distances from places where known infestations of the weevil existed the fall before at Audubon Park, and all materials that might have served as food for the insect through the winter were destroyed. Over 90 per cent of the beetles caught on these traps came from those placed within a few feet of the old infestations.

Two other observations made on 1918 crops indicate the slow dispersal of the sweet-potato weevil when plenty of food is at hand. One was in Orange County, Texas. Slips were taken from a "mother patch" and planted about 200 yards away. Vine cuttings were taken from the "mother patch" and the "slip patch" for another patch that was planted about 100 yards from the "mother patch" and 200 yards from the "slip patch". Tubers in the "mother patch" were fairly riddled by fall, and about 50 per cent of the tubers in the "slip patch" were infested when harvested, but no trace of the weevil could be found in the "vine patch". The other observation was made at Nine Mile Point, which is situated just above and across the Missis-

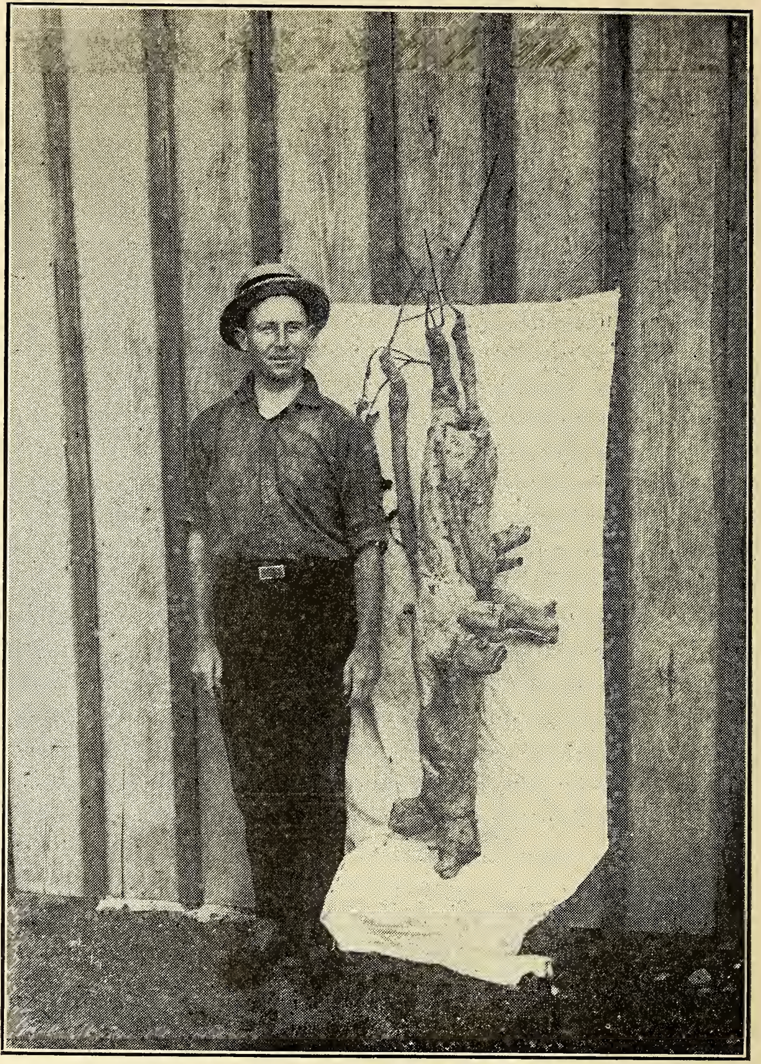

Fig. 4.—A main root of the perennial morning-glory, *Ipomoea pandurata.* Weight, 61 pounds; length, 4.8 feet; average of 3 circumferences, 2 feet. Grows on nearly or all types of soil in Southern Louisiana; and is a favorite wild food plant of the sweet-potato weevil.

sippi River from New Orleans. Cuttings were obtained from a "mother row" and two acres were planted adjacent to the "mother row". About 75 per cent of the tubers in the seven or eight rows next to the "mother row" became infested, while it was difficult to find a weevil in rows distant from the "mother row". Besides indicating the slow natural dispersal of the weevil, these observations indicate that there is greater likelihood of the weevil being transported from one place to another in slips rather than in vine cuttings.

FACTORS GOVERING AMOUNT OF DAMAGE.

During our observations no variety of sweet potato was found immune to attack by the sweet-potato weevil, though practically all growers questioned advanced the theory that all varieties commonly classed as "yams", such as the Porto Rico and Nancy Hall, were preferred to those of the Southern Queen type. Several growers, however, advanced an opposite view, and an observation made by W. T. Dillard and J. P. Landry, Assistant Entomological Inspectors, would seem to strengthen this idea. The Southern Queen was found growing intermingled with "yams" and was being severely attacked while the "yams" had been injured but slightly. During the survey, however, every variety grown in South Louisiana was repeatedly found severely infested.

With hardly an exception, tubers grown from slips were more severely infested than those grown from vine cuttings. This was doubtless not due to any quality possessed by either, but to other factors. Slips are always planted earlier and catch all straggling adults that might have been in the field. The crop is allowed to remain in the ground longer, unless harvested for the early market, and therefore, the insect has more time to multiply and do damage. The factor that possibly has more to do with bringing about the condition is, however, that the weevil on issuing from infested tubers in the bed deposits eggs in the slips and these are carried into the field and start early infestations in the planting.

The "mother row" method of propagation has aided, in no small degree, the sweet potato weevil in its ravages. This method is quite generally practiced in many localities of South Louisiana, and consists of the planting of the tubers in rows in the field.

Vine cuttings are obtained from these rows for the planting of the main crop. The worst feature of this method is that, if infested "mothers" are planted adjacent to the ground to be planted for the main crop, the insect is carried into and early established in the very midst of the main crop. The seed or slip bed method is a much better one to follow, as this tends to move the main planting away from any infested tubers that may be used as "mothers".

A sweet potato crop on an infested property should be harvested just as soon as it is mature because the longer it is left in the field the more damage the weevil is able to do. Growers that practice planting early and harvest for the early market, in July and August, almost always reported small losses, while their old fields, if left undisturbed, would be very heavily infested with the weevil by fall.

There is considerable variance in amount of injury done on different types of soil. Usually the loss is much less on the light sandy soils than it is on those of a heavy stiff character. The color and texture of a soil are not the determining factors, as many growers believe, but the difference is due to the natural entrances provided. The stiff soils crack much more from dry weather and root formation.

Other conditions being equal, injury is much less severe in years when there is a constant rainfall while the roots are forming—thus preventing the cracking of the soil—than it is during a year when the weather is dry during this period. It was noted in connection with some cage experiments conducted at Audubon Park that during dry weather, when the soil was cracked, practically all of the weevils would disappear from the surface, but would reappear when it started raining. The adults did not appear to like the wet ground and would usually be found clinging to the sides of the cages. Rains were so continuous in the fall of 1918, that crops practically free of the insect were harvested from fields in which the weevil was plentiful in the vines throughout the growing season. This condition existed on a number of farms under observation.

Freezes aid greatly in reducing the weevil under outdoor conditions. Practically 100 per cent of the different stages present in exposed tubers in a field at Lacombe were killed by the freeze of January, 1919. This was apparently not directly due to the low temperature, but to the fermentation of the tubers that followed the freeze.

Infestations of equal severity were found to exist in Louisiana both in the presence and absence of preferred wild host plants. Information obtained, however, indicated that the average loss over a number of years is considerably higher when one or more preferred wild hosts are present.

The activity of the sweet-potato weevil is reduced under low temperature conditions, that may exist in storage places, especially when the temperature is kept around 50 degrees F. Egg laying ceases and the immature stages develop very slowly.

NATURAL ENEMIES.

The sweet-potato weevil is remarkably free from natural enemies. A ground-beetle, *Scarites subterraneus* Fab.,* gained entrance to an experimental cage at Audubon Park and destroyed a number of adults in the experiment. An earwig was taken in another cage from which a number of weevils mysteriously disappeared, leaving several wing-covers behind. A mite was found infesting adults near New Orleans, but it had little or no effect on the life of the insect.

The Argentine ant was frequently observed attacking adults, but these adults were not injuried as a result. At no time was this ant found attacking the immature stages of the weevil in their natural habitat, though it would readily kill any placed within easy reach.

The chinch bug fungus, (*Beauveria globulifera* (Speg.) Pic.) † kills considerable numbers of adults when favorable conditions for its development prevail. This disease interfered greatly with cage experiments that were conducted at Audubon Park in 1919. The insectary and surrounding grounds became so thoroughly contaminated that beetles brought in hardly lived a week. Artifical inoculation experiments were made in Petri dishes, in cages placed on hedges in the field, and in the open field. Pure cultures of the fungus and natural cultures from infected beetles were used; the fungus being placed on sweet potatoes to which the beetles had access. No beetles were killed when the pure cultures were used, but from 50 to 100 per cent in the cages and from 70 to 100 per cent of those in the Petri dishes were killed by the natural culture. Very few beetles were apparently killed, however, by such cultures in the open field. The minimum length of time from the date beetles were placed with the fungus until their death was six days.

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* Determined by Dr. F. H. Chittenden.

† Determined by Dr. A. T. Spears, formerly of the Bureau of Entomology, U. S. Dept. of Agric.

WILD FOOD PLANT EXTERMINATION.

It was decided soon after the survey was started that it would be impossible to exterminate, or even satisfactorily control, the sweet-potato weevil near infested wild food plants. On the McIlhenny estate on Avery Island, for instance, the large rooted perennial morning-glory, (*Ipomoea pandurata*), was found to be well established and severely infested by the weevil. It was found growing on ditch banks, hedges, and fence rows over a large part of the cultivated land. The inspector was informed that sweet potatoes were grown quite extensively for canning purposes until about 1910, when the crop had to be abandoned for this purpose because such a large proportion was rendered unfit for use by the weevil. Since that time, however, a few sweet potatoes were grown each year for table use and the loss to these crops caused by the weevil ranged from 20 to 90 per cent every year. Arrangements were made with E. A. McIlhenny, manager of the Estate, to use these plants for experiments with herbicides and other methods of extermination.

The digging out and burning of the entire root system was first tried, but this was found to be very unsatisfactory and expensive. The larger roots were found to penetrate the soil from three to five feet and it was practically impossible to remove all parts capable of sending out sprouts. This method was found practicable only in the case of young plants whose roots reached a diameter of about one inch and a length of about a foot.

A number of different chemicals were tested as possible herbicides for this large rooted morning-glory. Among those used that proved valueless were acetic acid, acetic acid and bi-chloride of mercury, crude oil, powdered white arsenic, and iron sulphate (liquid and powered). Gasoline, carbon bisulphide and formalin (20%) gave fair penetrations, but insufficient to kill the entire root system.

A commercial preparation gave the best results of any compound tried. This contained, according to an analysis made by the Bureau of Chemistry, United States Department of Agriculture, the following ingredients:

Sodium Arsenite ($NaAsO_2$)	10.40%
Sodium Carbonate (Na_2CO_3)	6.19%
Fatty Anhydride	1.68%
Water	81.51%
Sodium Oxide combining Fatty Anhyd (Diff)	.22%

Thirty cubic centimeters applied in an excavation made in the top of tuberous root was found to be sufficient to kill the largest of them.

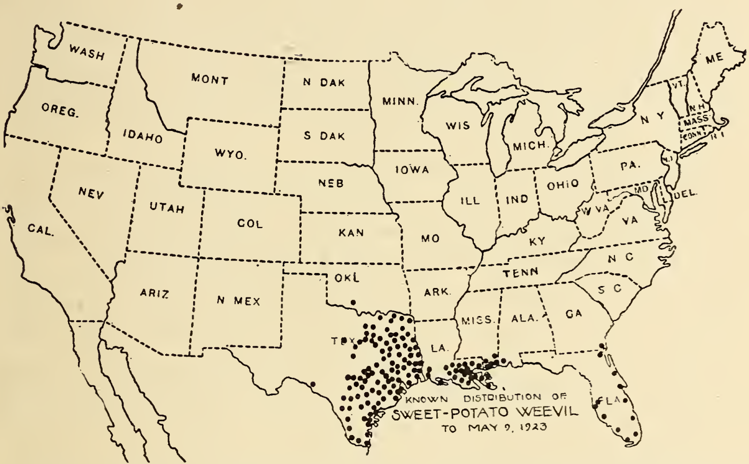

Fig. 5.—Known distribution of the sweet-potato weevil in the southern United States to May 9, 1923. (From a map furnished by Dr. F. H. Chittenden, Bureau of Entomology, U. S. D. A.)

Several strengths of commercial sodium arsenite containing 44.15% water soluble As_2O_3* and a preparation† made by boiling until clear (in an iron or granite kettle) 2 pounds sal soda, 1 pound powdered white arsenic, and 1 gallon water, were applied as sprays to the vines. All strengths used killed the vines down to the ground. Some of the stronger ones completely killed the plant down to the large root and in a few cases several inches of penetration were noted in the large root, but new sprouts were always sent up soon after the treatments were made.

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* Analysis made by Mr. A. P. Kerr, Chief Chemist, Louisiana Experiment Station.

† Formula from an article entitled "Herbicide Investigations", by Geo. P. Gray, in The Monthly Bulletin of the State Commission of Horticulture (California), Vol. 5, No. 4, pp. 133-139, 1916.

BAITS.

Upward of eighty different combinations of the materials named below were tested in cages at Audubon Park in 1919 as possible baits that might prove of value as an aid in controlling the sweet-potato weevil. Powdered white arsenic was the killing substance used in the mashes, which contained the following substances alone or in combination, with and without honey and inverted sugar:—wheat bran, corn meal, a filtrate, a steam distillate and a residue from grated sweet potato, ground or grated sweet potato, ground sweet potato vines, and the vines of the seaside morning-glory. Mashes with a small amount of peach, rose, strawberry, orange, lemon, raspberry, almond and vanilla flavoring extracts added were also used. The adults fed but slightly on any of these mashes, none of them being as attractive as the whole sweet potato.

Dehydrated and raw sweet potato tubers dipped in solutions of bichloride of mercury (.002%) and sodium arsenite (.02%) were used. The adults did not feed on the dehydrated tubers. Soon after the raw tubers were treated no preference was shown between the treated and untreated, but all the live weevils had collected on the untreated tubers within 24 hours. This was probably due to the action of the chemicals on the tuber. Forty per cent of the weevils were dead at the end of 24 hours and 20 per cent were practically so.

Powdered white arsenic applied to gashes made in whole tubers gave promising results as a poisoned bait when used in cages. Two diverging gashes made lengthwise the tuber, and pulled slightly open if they did not gape naturally, seemed the best method of preparing the tuber for the poison. In putting out the treated tubers, the gashes were placed next to the ground. The arsenical did not appear the least bit offensive to the beetle, while the freshly cut root was much more attractive than uncut ones. Within a few hours from 80 to 100 per cent of all the beetles in the cage would be collected and feeding in the gashes. This experiment was repeated a number of times and the mortality ranged from 75 to 80 per cent in each case. Sodium arsenite was substituted for white arsenic but it soon acted on the tubers, rendering them unattractive to the beetles. Whole sweet potatoes were always placed in the cages as checks.

TRAPS.

Sweet potato tubers were used in trapping adult sweet-potato weevils in the field at Audubon Park in 1919 and 1920. The tubers were placed along ditch banks, hedges, and elsewhere, and covered with any rubbish that was handy. The tubers were visited twice a week and the beetles collected. Each year the majority of the weevils were caught between March 15 and April 1. All potatoes bearing weevil punctures were collected and destroyed every three weeks in order to prevent breeding in the traps. In 1919, 324 tubers were put out and from them 84 adult beetles were collected. All vines and refuse of the crop were allowed to remain in the field the fall before, as is the practice on many farms. In 1920, 74 tubers were put out and from these 330 beetles were collected. Of these, 281 were females. The 1919 field was quite thoroughly cleaned of all refuse from the crop.

Indications are that traps can be used effectively to rid a field of wintered-over beetles when no food materials are allowed to remain in the field after the preceding crop is harvested. Traps would doubtless be worthless in the presence of infested wild host plants and uncleaned potato patches. Tubers treated with white arsenic, as discussed under "Baits", could be used as traps where no livestock of any description is allowed in the field and the grower did not have time, or want to take the time, to collect the beetles. These poisoned sweet potatoes would also aid in ridding a field of field mice and rats.

CULTURAL CONTROL EXPERIMENT.

That the sweet-potato weevil can be satisfactorily controlled, and possibly eradicated, by the use of certain cultural methods, was indicated by an incompleted experiment underway in St. Tammany Parish when the Government was forced to discontinue its investigations of the weevil in Louisiana on June 30, 1920. The writer inspected the farms included in the project the first of the following December and checked up the results. The pest had apparently been eradicated on several properties and greatly reduced on others. On farms where losses occurred the plan of control was, almost invariably, not carried out in every respect. The importance of every step included in the plan of control was well demonstrated in the results. A loss of practically 100 per cent occurred on a farm where no effort was made to control the pest, whereas, on a nearby farm where the plan was followed, the pest was apparently eradicated. The control plan consisted mainly of the following operations, in which Government inspectors aided the growers:—

(1) The destruction of vines before harvesting the 1919 crop by grazing, pulling them up and feeding them to stock, or burning them after they were dry enough.

(2) The sorting out and destruction of all infested tubers at digging time by feeding them to stock or burning; none but apparently sound roots being stored.

(3) Tubers to be used for planting stored separately from the remainder of the crop.

(4) Old field thoroughly cleaned by hogging off.

(5) All storage bins and banks thoroughly cleaned immediately after the crop was used up or disposed of and the refuse burned.

(6) Seed resorted at bedding time. Potatoes bedded as late as possible.

(7) Seed bed located as far as possible from where any infested material existed the year before, and the same precautions usd in selecting the locations for the slip and vine fields.

(8) Seed bed destroyed immediately after it had served its purpose.

CONTROL.

The control of the sweet-potato weevil is a comparatively simple matter; especially in the absence of preferred wild host plants and on farms with considerable acreage under cultivation. The insect has well developed wings, but seldom, if ever, infests new farms or localities by flight. The weevil will only make its own way from one farm to another when sweet potatoes are grown in fields near each other or when wild host plants inhabit the land lying between. A number of growers were encountered, while the survey was underway, who claimed to have rid their properties of the pest by discontinuing the growing of sweet potatoes for one year. This ''skip-a-crop'' method would probably only be effective when the farm was well separated from other infested properties, when wild host plants were absent, and when no volunteer sweet potatoes were permitted to grow on the place during the year when sweet potatoes were not grown.

In some sections of Louisiana, as in some sections of St.

Tammany Parish, the farms of many growers of sweet potatoes are too small to practice crop rotation, but these farms are located some distance apart in many cases. Under such conditions, the "skip-a-crop" method is probably the best way to eradicate the pest. In other parts of the State, the farms are close together, have narrow fronts but extend some distance back. Under this condition, the strictest co-operation of all growers of the settlement is necessary to even control the pest. Under both of these conditions, the loss can be greatly lessened by following as closely as possible the measures given below. Little relief can be expected from the employment of control measures on lands infested with preferred wild host plants, unless these plants are first exterminated.

The best time to start applying measures for the control or eradication of the sweet-potato weevil is at harvest time. No vines should be buried in the furrows or allowed to remain in piles on headlands, but should be grazed off with cattle, pulled and fed to livestock, or pulled and burned when dry. At harvest time, all infested tubers should be sorted out and immediately disposed of by feeding them to livestock or by burning. All tubers severely infested should be burned or boiled, if to be offered to livestock. Neither hogs nor cattle will eat very badly infested roots, but will brush them aside and, because of this, adult weevils will often escape. Immediately after the crop is harvested a sufficient number of hogs should be placed on the field to clean up all refuse from the crop.

Best results can be expected when the entire crop is disposed of and the premises thoroughly cleaned some time before it is time to make the seed bed or plant the crop, and the longer the place is kept free of any tubers, slips, and other material that may be infested with the weevil, the better. The following methods are recommended in order of preference for propagating the next crop.

Use vine cuttings from weevil-free locality, making planting in July.

Use slips from weevil-free locality.

Obtain seed potatoes from weevil-free locality.

When home grown seed is used it should be carefully selected at harvest time, stored separate and resorted at bedding time.

Much care should be exercised in selecting locations for the seed bed, slip and vine fields. Each should be located as far as possible from the others and from other possible infestations. As soon as the slip bed has served its purpose, it should be hogged off, or tubers rooted out and fed to livestock. A few trap potatoes should be placed on or near the old slip bed location immediately after it is destroyed to catch any adult weevils that might have emerged, thus preventing their possible migration to the nearest patch of sweet potatoes.

The mother-row method of propagation is not recommended, but if it is used, the planting should be located similarly to the seed bed, and destroyed likewise when no longer needed. Nothing but tips of vines cut not closer than ten inches of the base of the vine, should be used for cutting.

ACKNOWLEDGMENTS.

Information regarding the distribution of the sweet-potato weevil in foreign countries and in the United States was obtained from Farmers' Bulletin 1020 of the United States Department of Agriculture (Chittenden) and the Quarterly Bulletin of the State Plant Board of Florida, Vol. II, No. 1 (Newell). The description of the stages is, as indicated, also taken from Farmers' Bulletin 1020. The remainder of the bulletin consists of observations and conclusions drawn from information collected by the writer and the inspectors named below who participated in the study of the weevil in Louisiana.

The Louisiana project was organized by W. R. Perkins, Director of Extension, and J. E. Graf and Thos. H. Jones of the U. S. Bureau of Entomology. Professor Perkins and Mr. Jones selected and recommended the appointment of the inspectors, the latter giving the men the necessary training and directing the work as State Leader until the writer was transferred to the State and placed in charge. The corps of inspectors consisted of J. P. Landry, M. Hull, M. J. Kerr, W. T. Dillard, T. H. Cutrer, C. F. Moreland, O. W. Rosewall, and Felix Dabadie.

The writer acknowledges his indebtedness to Messrs. Graf and Jones for many suggestions during the survey, and to the latter for suggestions in the preparation of this paper, as well as W. G. Taggart, Assistant Director, in charge of the Louisiana Sugar Experiment Station, and its Staff, for the many courtesies extended the investigational force while at work in the State with headquarters at this Station in New Orleans.

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AND
AGRICULTURAL AND MECHANICAL COLLEGE

AGRICULTURAL EXPERIMENT STATIONS

W. R. DODSON, Dean and Director

BATON ROUGE, LOUISIANA

MELILOTUS INDICA ON FALL PLANT SUGAR CANE

BY

W. G. TAGGART
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CHEAP NITROGEN FOR SUGAR PLANTERS.

It has long been known that an ample supply of available nitrogen is most essential in the growth of sugar cane; also that the amount of that element that a crop of cane can use economically is governed largely by the supply of soil water. For a number of years past, the price of nitrogenous fertilizers has been high, and some nitrogenous substances which are in common use as fertilizers on the sugar plantation have reached such high prices, as compared with sugar, that they are prohibitive. Every factor in reducing cost, or in increasing efficiency is important. The water-holding capacity of any soil is governed largely by its state of tilth, and tilth in turn is influenced by the amount of humus embodied in the soil. In any system of crop rotation where legumes are plentifully grown, all of the nitrogen necessary to large crop production can be drawn from the air, and sufficient humus added to insure good tilth at a comparatively low cost. Our old method of rotating one year of corn and cow peas with two or three years of cane, left a large deficit in the soil nitrogen account. If good crops were grown throughout the entire length of time required during the rotation period, we would find that the cane required about 154 pounds of soil nitrogen for its growth; the corn required, for a 25-bushel yield, 34 pounds of nitrogen in grain, shuck and cob; and the cow pea crop would draw from the soil about 25 pounds. In addition to the 25 pounds taken by the crop of cow peas from the soil, about 50 pounds are drawn from the air, and this is returned to the soil when the entire cow pea crop is turned under. In other words, we have removed from the soil in growing crops 213 pounds of nitrogen and returned to it from the air 50 pounds, leaving 163 pounds as decreased nitrogen content of the soil. A small amount of the nitrogen was supplied in rain water, and possibly some came from the air, through the agency of microscopic life. If all of this 163 pounds was bought in the form of nitrate of soda, it would require 1100 pounds of that material and would cost at the present time about $37.75.

That much draft on the soil fertility of each acre distributed over a four-year period makes a very heavy tax, and is one that no farm can stand. With these facts before him, Director Dodson several years ago, instructed that we try to find a means of getting more legumes into our rotation, and suggested that we try to grow a clover cover crop on fall plant cane.

Crimson clover, Red Clover and Yellow sweet clover (*Melilotus indica*) were tried for this purpose.

Crimson clover grew well, but its habit of stooling so profusely injured the stand of cane, and while under very favorable conditions the growth of cane after crimson clover as a cover crop showed an increase in yield, the average of a number of years' work showed a loss.

Red clover does not stool so heavily, nor does it grow off as rapidly as crimson clover, except in the event of a very early spring season. In one instance of such a spring, an increase of 1.20 tons of cane due to red clover was secured; but an average of several years showed this crop to be of no value for such purpose.

Melilotus indica, called both yellow sweet clover and sour clover, known by many planters in this state as a weed and regarded as a pest, and until a few years back cursed along with "winter weed", proved of great value as a cheap nitogen gatherer. It adapts itself nicely as a leguminous catch crop without interfering with the usual rotation now in practice.

(In order to avoid confusion and save repetition this plant will be referred to throughout this bulletin as Melilotus or by its full botanical name *Melilotus indica.*)

Careful tests at the Sugar Experiment Station show that a crop of Melilotus planted on fall plant cane in October and turned under in the spring, will add to the soil from twenty thousand to twenty-seven thousand pounds of green matter, and that that green matter contains over one hundred pounds of nitrogen, equivalent to 667 pounds of nitrate of soda. This large amount of plant-food as has been estimated by various men who have tried it out costs from $1.25 to $3.00 per acre.

While the use of *Melilotus indica* in this way is new and novel to the sugar crop, it is by no means a new use for this valuable nitrogen gatherer. One of the most striking examples of the benefits to be derived from it is shown by a California publication in which some carefully conducted experiments are reported, an abstract of which is as follows:

	Yield Corn Five-year Average Percent	Yield Hay Sorghum One-year Percent	Yield Sudan Hay One-year Percent
Non-legumes and 123 lbs. Nitrogen	20.8	54.3	21.3
Non-legumes and 41 lbs. Nitrogen	19.0	11.8	21.7
Melilotus indica	65.7	47.3	19.1
Non-legumes and 82 lbs. Nitrogen	33.4	31.9	24.9
Average of increase due to all winter cover crops was,*			37.7
Average of increase due to commercial nitrogen was, ...			29.6

One hundred and sixty-three pounds of nitrogen per acre gave as an average for a six-year period 51% increase, while the plots where *Melilotus indica* was used, gave an average increase of 57% without the addition of any nitrogenous fertilizer. (California bulletin 292.)

Experiments conducted at the Sugar Experiment Station for five years show that this crop can be depended upon by the sugar planters to do for them what it has done for the California investigators.

In the following table are given comparative yields of cane where Melilotus was used as a catch crop and 250 pounds of acid phosphate added, compared with check plots treated with 250 pounds of acid phosphate, but no nitrogen.

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* Other winter cover legumes were included in this average.

FIELD DATA.

	Number of Stalks Per Acre				Tons of Cane Per Acre		Per Cent Sucrose in Juice	
	Spring Count		Fall Count					
	Clover Plot	Check Plot	Clover Plot	Check Plot	Clover Plot	Check Plot	Clover Plot	Check Plot
1917..	9493	9004	20464	13935	16.67	8.22	10.21	10.09
1919..	13933	8781	10308	9827	14.1	11.94	10.10	10.20
1920..	7101	7405	15913	15057	9.09	8.86	12.52	12.45
1921..	(3654)	(3871)	(9413)	(17028)	(8.04)	(12.67)	(12.5)	12.67
1922..	5635	5433	19413	16203	16.36	10.46	10.25	11.31
*Av..	9041	7656	16525	13711	14.06	9.87	10.77	11.01

* 1921 not included.

Per cent increase due to Melilotus, 41.3.

In 1918 an effort was made to get a maximum growth of Melilotus, or in other words, the Melilotus was allowed to grow until very late spring, when it was in full bloom. By so doing the stand of cane was severely injured and the experiment was abandoned.

Figures for 1921 are not included in the average. Until that year home-grown, uncleaned seed had been used and always grew satisfactorily without inoculation. That year clean seed were bought and sown without inoculation, a good stand was secured, but only three rows next to a ditch and a border next a headland showed nodules. All the Melilotus where no nodules occurred turned yellow and probably a third of it died. These results are valuable and are reported here, for they may explain to some planters why they have not had success from the use of Melilotus. It is well to add that a great deal of Melilotus has been planted in the belt without inoculation, and that most of it has done well. The crops of this station of 1922 and 1923 were inoculated with fine soil taken from a field where Melilotus grew well the year before.

The nitrogen contained in Melilotus is in a form that becomes available just as a large sugar cane crop needs it. In fact in that respect this form of nitrogen seems to be ideal for the purpose. Experiments conducted at the Illinois station show that nitrogen from white sweet clover (*Melilotus alba*) becomes available steadily throughout four months. Figures given in one of their bulletins are as follows: Analysis of soil April 26 for nitrate nitrogen before clover was turned under, showed 38.7 pounds. And after clover was turned under, as follows: May 30, 76.8 lbs.; July 1, 67.2 lbs.; July 14, 51.3 lbs; August 12, 143.61 lbs. Check soil, 10.1, 11.8, 18.6, 11.8 lbs. These figures show that practically all the nitrogen carried into the soil by the clover crop had undergone nitrification and had become available as plant-food in 108 days. In Louisiana where the warm weather opens up earlier than it does in Illinois, the chances are that nitrification would take place faster than it did in Illinois. At any rate, the analysis of the cane grown here shows that the large quantity of nitrogen is made available early enough to insure against the possibility of unduly green cane for the mill.

A large number of sugar planters have already given attention to this valuable crop, and a brief statement from a few of them may prove of benefit to others. The first planter to take up this crop was Clark D. Liebermuth, Salsburg Refining Co., who reports:

> "Increased yield due to sweet clover (Melilotus); estimated two to five tons in plant cane. No other fertilizer applied with clover. No effect on stand of cane, provided clover is turned under early as is winter grass. No tonnage measured on stubble crop, but better tilth of soil noted during two years. Increase in cost of cultivation negligible. Seed used 25 pounds per acre. Clover (Melilotus) removed by Magnolia cane scraper."

Walter Godchaux, reporting for Raceland, says:

> "Increased yield due to sweet clover (Melilotus) 22%. On twenty-five ton yield five and one-half tons. No fertilizer applied with clover (Melilotus). No injurious effect to stand except in one instance, on Utopia, during extremely dry year, decreased stand of 25% noted. In all other instances where clover (Melilotus) was used during the past few years, we have noticed no difference in stand. Average cost per acre, including cost of seed and extra labor, $1.50 per

> acre. Do not think cost of cultiviation is increased or decreased materially. Sour clover (Melilotus) is scraped off with plant cane scraper.''

Mr. Godchaux reports one instance where a loss of 1.5 tons per acre at Raceland was shown, but explains that the section in this experiment was near the sugar house and had been treated with filterterpress mud and manure compost, and that it was possible that non-clover section received more manure than did clover section. And, too, it is a well-known fact that Melilotus will not draw nitrogen from the air in any appreciable quantities if planted on soil extremely rich in nitrogen.

Stanley F. Morse, in 1921, reported increased yields due to Melilotus, at another one of the Godchaux places, of six tons, or 30%. He also showed 7.5% increase at the Colonial Sugar Company.

Andrew H. Gay reports that he has planted Melilotus one year and got a wonderful stand, at a cost of one dollar for seed and twenty-five cents for sowing. Has, as yet, no estimate on yields.

> Judge Gilbert reports: ''Have used clover (Melilotus) for two years and find it of some help in keeping down grass and of benefit to the soil. Have no special data on difference in tonnage.''
>
> J. T. Guyton: ''Used clover (Melilotus) last fall at rate of 20 pounds seed at 6-cents a pound. Clover (Melilotus) taken off and turned under in usual way that we handle fall cane when we do not use it, for we always have a crop of winter grass to be scraped off and turned under. The only cost is for seed, and small cost for sowing. As far as effect on stand is concerned, we find there is no difference. In breaking out middles of the land that has had clover (Melilotus), we find that the land is in better condition than land that has had none.''
>
> J. W. Supple: ''Never determined yields of cane with or without clover (Melilotus) crop. Planted small way in 1921; large way in 1922. Never used commercial fertilizer with clover

> (Melilotus), nor did it affect stand. Cost of planting very small, as one man will sow 12-15 acres a day by hand. We sow 18-20 pounds per acre. No extra cost to turn under, as we scrape rows in usual way with Avery cane scraper, wrap middles and off-bar cane and clover completely. No increase in cultivation costs."

Lewis Murrell, who has tried out Melilotus on quite a scale with a two-ton cane increase, when talking about the use of Melilotus, says: "Personally I believe that in three or four years all our old lands will become new lands again."

O. C. Roemer, County Agent for Iberville parish, conducted a series of tests with Melilotus on fall plant cane. The average increase of eight tests made by him was 5.3 tons, and the minimum was 3.1 tons. He has placed orders for 150,000 pounds to be used in his territory the coming fall.

HOW TO USE MELILOTUS.

Melilotus seed, at the rate of twenty to twenty-five pounds, should be sown broadcast over the cane lands after the rows have been built up. The seed can be covered by the ordinary roller, though the cultipacker insures a better job. Melilotus seed should not be sown on extremely cloddy or rough land, for in such a case the chance of losing seed due to poor covering is great.

In case Melilotus has not been grown with success on a soil, it is a good practice to inoculate either the soil or the seed. This can be done satisfactorily and with the least cost by using top soil from an old field of Melilotus or alfalfa where it is known that the soil was inoculated, or in other words, where the crop grown the year before produced nodules and grew well. Soil from such a field should be taken from the first six inches and dried IN THE SHADE until it will crumble nicely. Sift this soil, if necessary, and sow over the land at rate of 200 pounds per acre just before covering or rolling. It will be easier and probably cheaper to moisten the seed with a sticky molasses solution made of one gallon molasses and five to ten gallons of water. This solution should be just sticky enough to be felt between the fingers. After moistening the seed sprinkle into them the dried and pulverized soil, then allow them to dry *in the shade* before sowing.

WHEN TO TURN UNDER CLOVER.

Melilotus should be allowed to make as much growth as possible without taking the chance of injuring the stand of cane, or jeopardizing the progress of field work. On large-scale planting, the planter cannot afford to wait too long before scraping, but he should realize that the longer he lets his Melilotus grow the more nitrogen and organic matter will accumulate. An ideal time for turning under Melilotus is during the early blooming period. At that time the plant has reached a high degree of maturity and is rich in nitrogen. If it will not jeopardize the general plan of work, it would be profitable to hold the Melilotus until some small injury is done to the stand of cane, for tests at this station show that cane after Melilotus was turned under on March 22, though beginning with a poorer stand, produced more canes by harvest and a greater yield per acre than did cane after clover turned under twenty days earlier.

CANE AFTER MELILOTUS IN 1922.

Date Turned	Spring Stand		Fall Stand		Tons Per Acre	
Under	Clover	Check	Clover	Check	Clover	Check
March 2	6190	5453	18951	16203	14.08	10.46
March 22 ...	5635	5433	19413	16203	16.36	10.46

It is important to know that under certain conditions nitrogen may escape from the soil as a gas. This is due to certain denitrifying organisms, and it is claimed that large losses of nitrogen are likely to occur when heavy crops are turned under in a poorly drained soil. For this reason it is not advised that Melilotus be used on soils that, from lack of drainage, are likely to become water-logged.

If we are to get the best results from our labor, our soils should not be allowed to become lacking in any one of the essential elements. Next to nitrogen, sugar cane in Louisiana needs phosphoric acid. Melilotus will build up the nitrogen account and it will bring up some phosphoric acid from the subsoil, but it cannot add phosphoric acid. Any soil that is entirely lacking in any one of the essential elements will not produce; and a soil that is poor in any one of the essential elements, even though it is rich in all of the other elements, will not grow maximum crops. Plant cane draws more phosphoric acid from the soil than does any of the other crops in our rotation, and we should take care of that account by adding about two hundred pounds per acre of high grade acid phosphate to our plant cane after Melilotus cover crops.

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LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE

AGRICULTURAL EXTENSION DIVISION
W. R. PERKINS, Director of Extension
In Cooperation with the United States Department of Agriculture

BATON ROUGE, LOUISIANA

"DRY ROT" IN BUILDINGS AND BUILDING MATERIAL

BY

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PLANT PATHOLOGIST

DISTRIBUTED IN FURTHERANCE OF THE ACTS OF CONGRESS OF MAY 8 AND JUNE 30, 1924.

"DRY ROT" IN BUILDINGS AND BUILDING MATERIAL

By C. W. EDGERTON

The deterioration of lumber by decay, especially lumber that is used in the construction of buildings, is a matter of importance in Louisiana. During the past few years, a number of reports have come to the Experiment Station in regard to buildings rotting rapidly. The buildings affected have included dwelling houses, school houses, churches, store buildings, and one of the University buildings at Baton Rouge. In some cases, the buildings were materially weakened before the seriousness of the rot was appreciated, while in other cases the trouble was observed and checked in time. In a few cases, the repairs that were made only furnished new lumber for the rot to destroy. The deterioration is caused by fungi the growth of which is favored by high temperatures and abundant moisture, conditions that are commonly present in this state.

There are many different types of lumber deterioration but practically all of the trouble in buildings is confined to a single one. This is the type in which the rot spreads rapidly throughout a building and is not confined to those portions in contact with the ground or kept in a wet condition. This is often spoken of as *dry rot* due to the fact that the affected wood dries out rapidly after it has passed through the decay. As a matter of fact, while the decay is in progress, the wood is wet even to the point that water may drip from it. For the lack of a better term, however, the name, *dry rot,* will be used in this bulletin.

Dry rot can be prevented by taking proper precautionary measures. It can also be checked after it has gained entrance to a building though this is often at a considerable expense. It is the object of this bulletin to describe the trouble and its cause and to outline the methods of prevention and control.

The Cause of Dry Rot

Dry rot deterioration of lumber is caused by a fungus known technically as *Poria Incrassata.* This fungus is rather widespread and common in the Southern States and is likely at any time to cause trouble when the surrounding conditions are favorable for its development. The fungus is easily recognized by the abundance of white mycelium or mold which is present between the walls or in any protected place in an affected building.

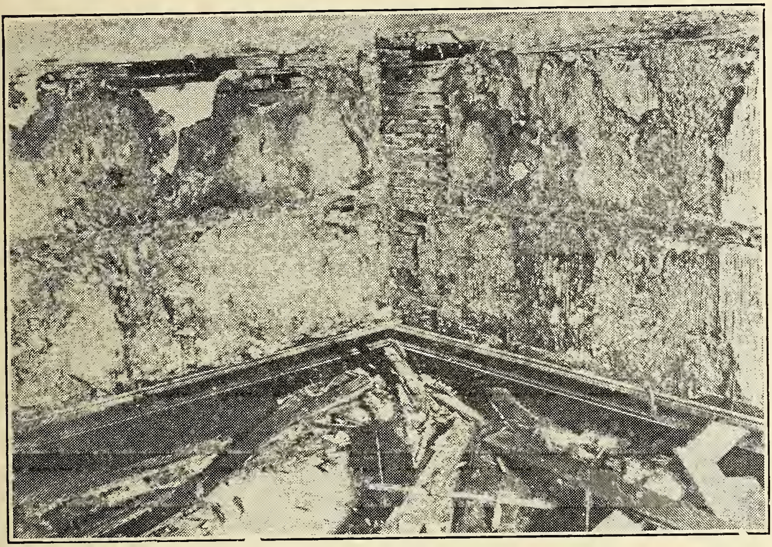

Fig. 1.—Corner of a room showing the mycelium of the dry rot fungus between the wainscoting and plaster within a partition wall. The fungus also shows on the wainscoting boards lying on the floor.

To understand dry rot, it is necessary to understand the method or manner of growth of this fungus. The fungus develops and spreads by means of white mats of mycelium which spread out in a fan-shaped manner. This mycelium develops very rapidly in places that are enclosed and are not subject to drying. In a building, such places are between the floor layers, between the partition walls and around enclosed foundation timber. These dense mats of mycelium fill every crack and crevice between the boards in such areas. In figure 1 is shown a partition wall with the wainscoting removed. The fan-shaped mats of mycelium show on the plaster and also on the backs of the wainscoting boards that are lying on the floor.

As the fungus advances, it obtains its food material from the wood upon which it is growing. This action on the wood constitutes the decay. The wood turns brown in color and becomes very brittle. In the final stages of the rot, the wood can be crumbled between the fingers. Usually the wood decays very rapidly.

In order to act on and decay dry lumber, the fungus requires a very large amount of water. This it obtains from its connection with the ground or some other wet substance. Near the ground, the fungus usually develops thick strands of fungus tissue called rhizomorphs. These rhizomorphs spread out over the wet ground and form the connecting link between the water supply in the ground and the rapidly advancing mycelium. No matter how far the mycelium spreads out or how high in a building it travels, it must maintain a connection with a water supply. These rhizomorphs are usually about the size of a pencil or smaller but may become nearly an inch in diameter. Some of these rhizomorphs are shown in figures 3 and 4. When the fungus is growing and advancing rapidly, these rhizomorphs are usually so wet that water can be squeezed from them. This ground connection becomes of great importance in the control of dry rot.

An Example of Dry Rot

Dry rot can possibly best be appreciated by describing in detail an actual example. An excellent opportunity was had to observe this trouble in the wood portion of one of the brick buildings of the University, at Baton Rouge, during the summer of 1923. In the repair work that was necessary, all infected portions were traced out and removed and the actual conditions in all parts of the building were ascertained.

That something was wrong with this building was first perceptible in the spring of 1923. The trouble was evidenced in two ways. *First,* it was noticed that objects left on shelves in one of the basement rooms became covered with a dense mat of mycelium and were cemented to the shelving and back wall. Some valuable electrical instruments were ruined by the mycelium running through them (Fig. 2). *Second,* it was noticed that the double floor between the basement and the first story was rapidly becoming weak and was breaking through in places. As the school term was in progress, only temporary repairs were made at the time. In August, after summer school was over, a more thorough inspection was made and the building was repaired so as to prevent a reoccurrence of the rot.

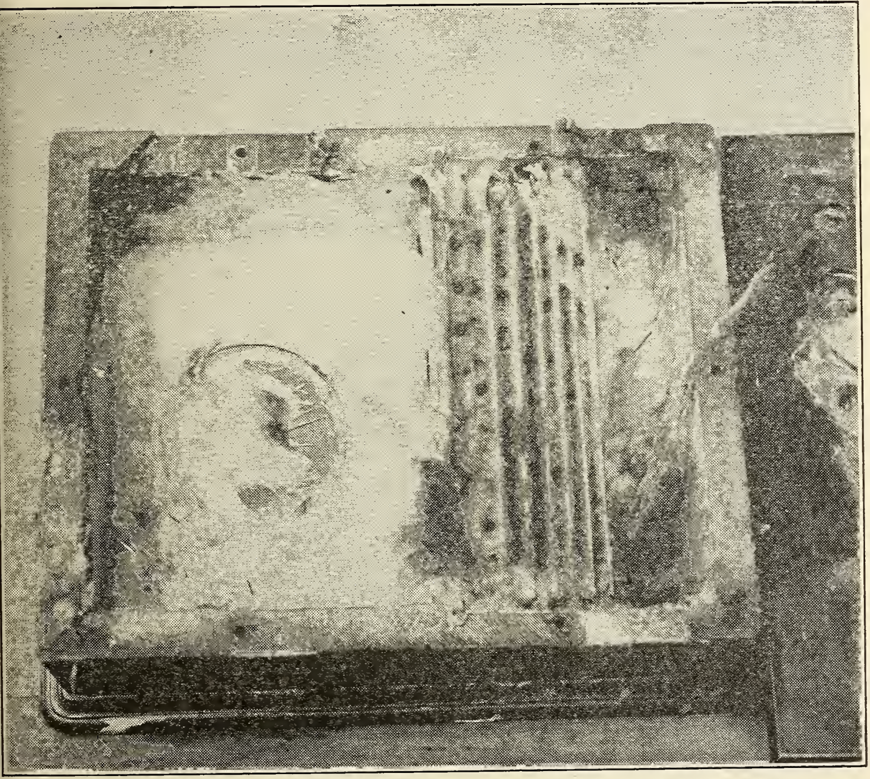

Fig. 2.—Electrical instrument (watt meter) with the top removed, filled with the mycelium of the dry rot fungus. The mycelium grew into the instrument from the infected shelf on which it was placed. About one-third natural size.

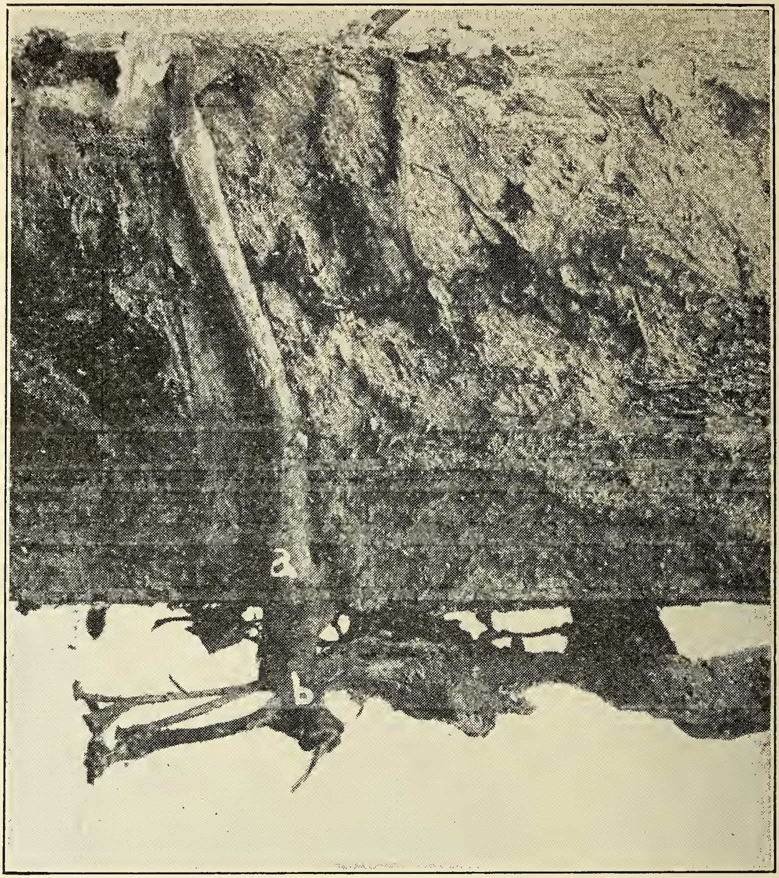

Fig. 3.—Rhizomorph of the dry rot fungus (a) at the point of attachment to the ground (b). One-half natural size.

The basement extended under only one end of the building and this was separated from the unused portion under the building by a double-board partition. This partition came within one to two inches of the ground. It was on the timbers of this partition that the fungus first became established and all the infected areas in the building had a direct connection with this area. The fungus had developed a number of large rhizomorphs which were firmly attached to the ground and extended over the surface of the partition and into the floor above. The rhizomorphs shown in figures 3 and 4 were all taken from this building.

Where the fungus had reached the floor of the first story, it had spread out in all directions, growing between the floor layers and in the enclosed spaces in the partitions between the various rooms. Traveling up the wood partitions, in one place it had reached the floor of the second story. On the first floor, it had covered an area about

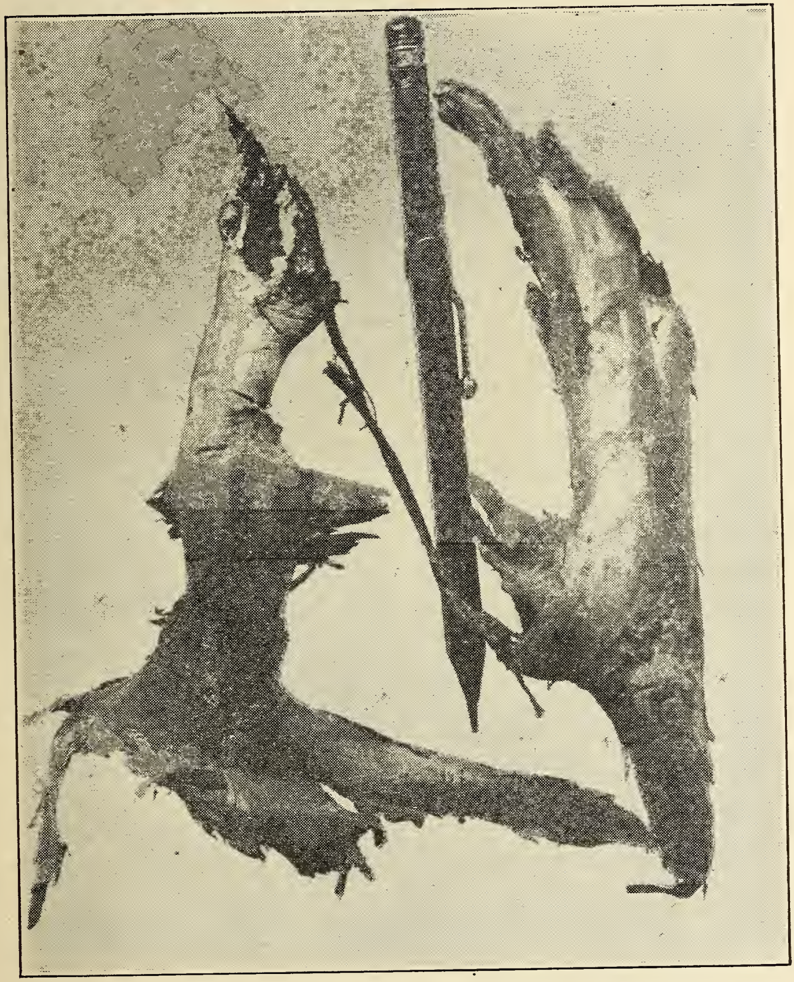

Fig. 4.—Large rhyzomorphs of the dry rot fungus. Slightly reduced.

twenty-five feet in diameter. In the center of this affected area, most of the wood was in very bad condition. Some of it could be crumbled readily between the fingers.

In all places where the fungus had sufficient water supply, it was growing very rapidly. At one place in the building, a new double floor had been laid at the time the temporary repairs were made in April. In August, when the permanent repairs were made, the fungus had grown for a distance of three to four feet between the new floor boards. At this rate, it would not have taken many months for the whole building to have become affected. In other places where the repairs had broken the connection of the fungus with the ground, the mycelium had practically ceased growing and had become dry.

The lumber which had been used in the construction of this building was largely cypress and heart pine. Both kinds were affected. The cypress apparently showed no more resistance to this type of decay than did the pine. It is known that practically all of the common woods are readily affected by this rot.

Another point of interest noted in regard to this building was that the ground under the portion that had not been finished into a basement was entirely infested with the dry-rot fungus. Pieces of new lumber dropped on this ground in April were covered with the mycelium between the ground and the wood, in August. In figure 5 is shown a piece of board that was left during this period and shows the heavy growth of mycelium. This point is of interest from the control standpoint.

In repairing this building, the wooden partition that was close to the ground was entirely removed and was replaced by a solid brick wall. Then all of the infected wood in the building was taken out and burned and was replaced by lumber that had been painted with creosote. Creosote was also used liberally on every piece of lumber that was exposed. Finally the ground under the building was treated with creosote in order to kill as much of the mycelium in the soil as was possible. No reoccurrence of the trouble is expected.

Lumber Yard Infections

Piles of lumber in lumber yards and at saw mills are also frequently infected with the dry rot fungus. This is especially true in yards where no special care is taken to prevent it, where the lumber is piled on the ground or on wooden cross pieces that are in contact with the ground. Lumber from such yards when shipped out over the country carries the infection with it. If any of this lumber is placed in the basement of a building where the moisture is sufficient, the fungus will start to grow and soon the whole building will be affected. It is in this way that many of the infections in buildings are started. This trouble is so serious that an inspection of lumber yards by some state department might be advisable.

Controlling Dry Rot

The control of dry rot is to be considered from two angles, the prevention of the trouble and the control after it has once gained an entrance to a building.

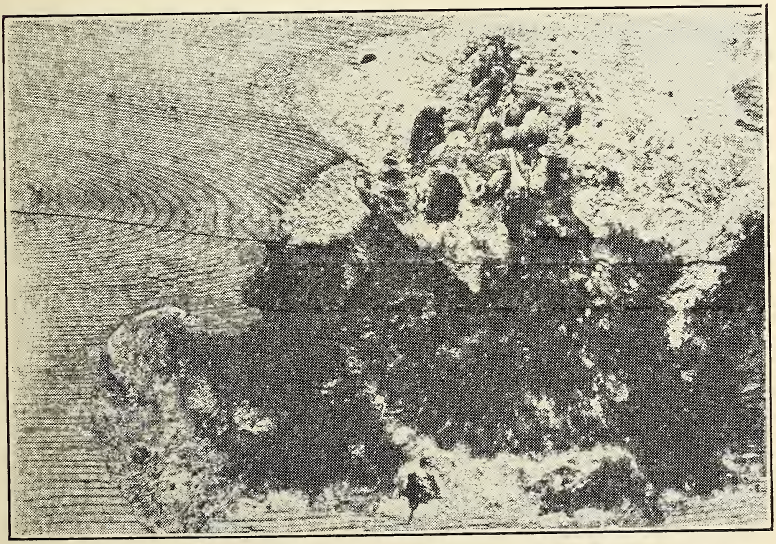

Fig. 5.—Mycelium of the dry rot fungus which had developed in four months on a twelve inch board which had been dropped under an infected building .

Prevention

Dry rot can usually be prevented if the proper precautionary measures are taken at the time the building is being erected. This is much more satisfactory and much cheaper than trying to stop an infection that is already started in a building. The precautionary methods that are important include the following:

1. All lumber that goes into a building should be inspected carefully. If any of it shows the characteristic white mycelium, it should not be used. As a matter of fact, it would be wiser to refuse the whole shipment of lumber and obtain it from some yard in which the lumber is stacked so that the dry rot will not affect it. If more of such lumber were refused, the lumber yards would be more careful.

2. Foundation timbers or any lumber that is to be placed within twelve or eighteen inches of the ground should be creosoted. There are creosoting plants in the South from which such timbers can be obtained. Creosoted lumber will not be attacked by the dry rot. A few dollars added to the original cost may result in a considerable saving in the end.

3. If buildings are to be placed close to the ground, it is better to use concrete or brick as high as possible instead of wood. During recent years there has been a tendency to place houses, especially of the bungalow type, close to the ground. Usually the outside wall is extended to the ground. The closeness of the timbers to the ground, combined with the poor ventilation, permits the dry rot to develop rapidly if it happens to be present. A house of this type has been seen by the writer in which the floor broke through in less than two years after being built.

4. Plenty of ventilation around the foundation timbers is essential as this keeps them dry and less likely to become affected by the dry rot.

5. Lumber or other wood material should never be piled under a house. Such material makes a very convenient path for the dry rot fungus to travel from the ground to the foundation timbers.

Dry Rot Control

After the dry rot has become established in a building, the control measures rest upon the eradication of the fungus with repairs that will prevent further growth and development. Usually by the time the trouble is noticed, certain parts of the building are in such a condition that repairs are necessary. Usually the trouble is first noticed by the floor or some of the timbers near the ground breaking through or giving away. In repairing an affected building the following measures are essential:

1. All infected lumber should be removed from the building and immediately burned. If the boards are not burned, they are likely to be carried away to other buildings and there start new infections. The infected timbers in a building are very easy to locate by the abundance of the white mycelium on the under or back surfaces.

2. In the repairs, regular creosoted lumber, or at least lumber painted with creosote, should be used.

3. In making the repairs, all wood material should be raised a foot or more from the ground. If this is impossible, concrete or brick should be substituted for the wood. Then if there is sufficient ventilation under the building, this will prevent the fungus from forming a connection with the ground and consequently hinders or stops its development. If this is not done and reinfection occurs, it will be only a short time until the new lumber used in the repair work will also be destroyed. This is possibly the most important point to be considered in the repair work.

Literature on Dry Rot

Much work has been done on the dry rot trouble by the Forest Products Laboratory of the United States Department of Agriculture. Anyone desiring further information on the trouble can obtain it from any of the following publications published by that office. These publications have been used freely in the writing of this bulletin.

HUMPHREY, C. J.—*Timber storage conditions in the Eastern and Southern states with reference to decay problems.* U. S. Dept. of Agr. Bul. 510. 1917.

HUMPHREY C. J.—*The destruction by the fungus "Poria Incrassata" of coniferous timber in storage and when used in the construction of building.* The Southern Lumberman, Vol. 49, No. 3, pp. 36, 37, 49-55. Feb. 1, 1923.

HUMPHREY, C. J.—*Destruction of lumber by decay.* Railway Purchases and Stores, March and April issues. 1923.

HUMPHREY, C. J.—*Decay of lumber and building timber due to Poria Incrassata.* Mycologia 15:258-277. 1923.

DECEMBER, 1924 LOUISIANA BULLETIN NO. 191

LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE
AGRICULTURAL EXPERIMENT STATIONS

W. R. DODSON, Dean and Director

BATON ROUGE, LOUISIANA

THE SUGAR CANE DISEASE SITUATION IN 1923 AND 1924

BY

C. W. EDGERTON, W. G. TAGGART and E. C. TIMS

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On account of the serious situation confronting the Louisiana sugar industry at the end of the season of 1924 as a result of a series of poor crops, it seems advisable to put on record the actual conditions with a discussion of the possible causes and the work that is being done to bring the crop back to normal. The poor crops have resulted in a great deal of discussion and various opinions have been expressed as to the cause or causes. Some persons hold the opinion that the sugar industry of Louisiana has reached a crisis and they freely predict that it can be saved only by a complete change of varieties. At the other extreme, some believe that with proper treatment of our present varieties, they can be brought back to a satisfactory condition. Some of the various opinions are founded on ideas and statements which are not justified by the facts.

If, as a result of the present situation, the present cane varieties are replaced by others, then a careful analysis of the different possible causes will be of value. Other sugar countries have had their troubles in the past which resulted in the change of varieties. In some countries, varieties have come and gone a number of times. The cause of some of these changes is known, but unfortunately, it is not perfectly clear for some of the others. Possibly the most outstanding example of a variety being discarded without definitely ascertaining the cause, was the abandonment of the old Bourbon cane in the British West Indies in the nineties. The cane of this variety went to pieces and at the time it was attributed to the rind disease, just as today the mosaic is getting the credit for our Louisiana troubles, yet no one today who knows cane diseases, believes that the rind disease was the cause.

If on the other hand, the D 74, Purple and Striped varieties remain, then a knowledge of the causes of the present situation may aid in a more rapid recovery and help to prevent future trouble.

Crop Conditions

At the close of the season of 1924, the crop conditions in the sugar belt of Louisiana were worse than they had been for a great many years. The crop of 1923 had been short while that of 1924 was almost a failure. The industry had suffered short crops before but probably never two in succession.

The crop of 1923 showed a low yield per acre, only 11.1 tons. This, however, was not as low as the crops of 1912, 1915, and 1919. The borer infestation was heavy and the infection with red-rot very high. The cane used for seed in the fall, as a result of the borer and red rot, was very poor, possibly in the worst condition it had been for years. Furthermore, this bad seed was planted in soil that had remained watersoaked through a greater part of the season.

The crop of 1924 started off poorly. The germination in the spring in many places was low and this resulted in many poor stands. Both the plant and the stubble cane showed the gappy stands. Following this bad start, in some localities many of the young plants died when they were from six to fourteen inches high. Then the growth during the whole season was very slow. There was considerable variation in growth in different fields and in different areas in the same field. There were spots with poor cane and spots with fairly good cane. The even growth which is characteristic of a good cane field was quite generally lacking.

There was also some variation in the cane in different sections of the state. In a few places, the cane was very good. Some cane cut up to 25 tons to the acre in favored spots in the lower coast district, while yields of 35 tons were expected on some of the reclaimed soils. In other sections, however, the crop was so poor that a considerable percentage was not worth cutting. This variation in different sections is best shown by quoting from the November 1 Crop Report, prepared by Lionel L. Janes, Agricultural Statistician of the United States Department of Agriculture.

"Sugar cane continues in better condition on the average in the Louisiana cane belt than in the outside parishes. A number of reports indicate that outside the cane belt there will be scarcely enough seed to replant the harvested area.

"The percentage condition of sugar cane in the cane belt by parishes on November 1, 1924, is as follows, comparison being with a normal condition of growth and vitality giving promise of a full yield per acre represented by 100 per cent:

"Avoyelles 26, Point Coupee 34, Rapides 31, St. Landry 23, West Feliciana 50, Ascension 41, East Baton Rouge 18, Iberville 39, West Baton Rouge 31, Iberia 40, Lafayette 23, St. Martin 24, St. Mary 38, Vermilion 28, Assumption 44, Lafourche 39, Terrebonne 55, Plaquemines 45, St. Charles 60, St. James 38, St. John 47."

The low condition of some of the western parishes such as Lafayette, Vermilion, St. Martin and St. Landry is worthy of notice. This will be considered in the discussion on weather conditions and mosaic later in this bulletin.

The sucrose content of the cane at grinding time in 1924 was running abormally high. Analyses of 15 and 16 per cent. sucrose and even higher, were being reported from some of the mills. This high sucrose content will offset to some extent the low tonnage.

The cane used for seed in the fall of 1924 was exceptionally good. There were comparatively few borers and the red-rot infection was low. When sufficient moisture was present, the canes germinated with more vigor than usual. This was particularly true in fields with selected seed. New plantings with nearly a perfect stand were seen before the middle of November. In some fields that were dust dry, seed planted early in October failed to germinate and deteriorated badly. Some of these, if not replanted, will doubtless show very poor stands in 1925. Fields, however, with sufficient moisture, either from local rains or irrigation, to start germination give promise of excellent stands of vigorous cane.

As a result of the poor crops of the last two years, some planters and others interested in the sugar industry have expressed the opinion that the Louisiana cane varieties have been degenerating for a number of years and that they are not now capable of producing as they did at an earlier period. The reasons as usually given are: (1) from year to year the cane has become more and more affected by disease; (2) the general practice of planting the poorest and most diseased cane has resulted in a weak or more or less degenerate condition. As to this point, a comparison of the crop yields over a considerable period will give the best information. In Table 1 are given the data on the Louisiana sugar crops for the last twenty-four years. These data were obtained from the Year Books of the United States Department of Agriculture. Besides giving the total yields for the whole period, the table also includes the yield per acre and the sugar per ton of cane for the period since 1911.

TABLE 1

CANE YIELDS IN LOUISIANA, 1901-1924

YEAR	Area cut for sugar	Yield per acre, tons	Sugar made tons	Sugar per ton pounds
1901			360,277	
1902			368,734	
1903			255,894	
1904			398,195	
1905			377,162	
1906			257,600	
1907			380,000	
1908			397,000	
1909			364,000	
1910			342,720	
1911	310,000	19.0	352,874	120
1912	197,000	11.0	153,573	142
1913	248,000	17.0	292,698	139
1914	213,000	15.0	242,700	152
1915	183,000	11.0	137,500	135
1916	221,000	18.0	303,900	149
1917	244,000	15.6	243,600	128
1918	231,200	18.0	280,900	135
1919	179,900	10.5	121,000	129
1920	182,843	13.6	169,127	136.1
1921	226,366	18.5	324,431	155.2
1922	241,433	15.6	295,095	156.2
1923	217,259	11.1	162,023	135.8
1924*		7.2	115,261	

*Crop Estimate of November 1.

An analysis of this table shows that in the period between 1901 and 1911, the yearly variation in yield was not very marked, but during the period since there have been a number of years with short crops, as for example, 1912, 1915 and 1919. It is also seen that in this latter period, there were some years with very excellent crops and that one of the best of these occurred as late as 1921.

If the sugar crops have been deteriorating, when did the decline begin? It might possibly be said with the first poor crop of 1912. If so, then it is difficult to account for the very good crops that have been grown since that time. The only other time to start the decline is immediately after the most excellent crop of 1921. However, the very adverse weather conditions of the past two years so complicate the situation that it is not possible to say what the crops would have been under normal conditions. As a matter of fact, the data on crop yields offer no proof of any actual deterioration or running out of the varieties. They do, however, suggest one thing and that is, that the various diseases are perhaps becoming more prevalent and in years favorable for their development, they may reduce the crop to a considerable extent. There is no evidence to show that free of these diseases, the cane will not produce just as well as formerly.

Causes of the Poor Crops

The following analysis of the causes of the poor crop condition follows a very thorough study of the situation in the whole sugar belt. The various sections have been visited many times from very early in the spring until grinding time in the fall. Furthermore a series of meetings were held in September, 1924, by members of the Experiment Station and Extension Division and the situation was discussed with a very large number of planters.

A number of factors have been suggested as possible causes of the poor crops. The ones which seem important are: weather conditions; unsatisfactory cultivation, drainage and fertilization conditions; cane borer infestation; and the attack of several cane diseases. While these different factors will be considered separately, it should be kept in mind that the actual crop condition developed as a result of a combination of these rather than any single one.

Weather Conditions

The weather conditions of both 1923 and 1924 were very unsatisfactory for cane production. 1923 was very wet, being one of the wettest years known, while 1924 was just the opposite being the driest year on record. The actual condition can best be given by quoting from the reports of the United States Weather Bureau.

In the summary for 1923, the conditions for that year are expressed as follows:

"The average precipitation (for 1923) was above normal in all months except January, which was slightly deficient. Except for 1905, the annual average precipitation was the greatest during the period of Statewide record. —There was too much rain for the best development of most crops, especially cotton and sugar cane. —Frequent rains at critical times prevented needy cultivation of sugar cane in numerous localities, so that the period of cultivation closed with numerous grassy fields. —Grinding of cane began in October and was generally completed by the close of the year, with yield below normal for the tonnage, which was light. A good fall planting of sugar cane was secured."

The soil remained water-soaked through most of the season of 1923 and consequently was in a very bad physical condition at planting time in the fall. The soil remained wet through a considerable portion of the winter of 1923-24 as January, 1924, was also a wet month. Following this period, however, the weather turned off dry and for the whole of the growing season of 1924, the precipitation was far below normal except in a few localities. In many sections, from February until the end of the season, every month showed a precipitation less than normal. The growing months of July, August and September, the months in which a heavy rainfall is needed, were particularly dry.

Quoting from the United States Weather Bureau report for the Louisiana section for August:

"The month was the warmest and driest August during the period of Statewide record. —The drought, beginning in June, this year, and continuing into September, is unprecedented for light summer rainfall in Louisiana during the period of the Statewide record of 34 years. The total of the averages for June, July and August, 1924, was 6.84 inches. The nearest to this for the same months, was 9.87

inches in 1902. The drought injured all crops. Sugar cane prospects were materially reduced."

The final Weather Bureau Summary for the year is not as yet available. The drought, however, continued through September and October and was not broken until November 20.

The drought did not affect all sections to the same degree. In some places, there were local rains which were of considerable benefit. In Table 2, is given the rainfall as published by the United States Weather Bureau, for a number of places in the sugar belt. Some of these figures do not show the actual conditions even for the surrounding territory on account of the small area covered by local rains. For instance, Baton Rouge is given a rainfall of 3.25 inches for August. Most of this was due to a local shower that was confined almost entirely to the city limits. Four miles away at Cinclare, the rainfall for the month was only 1.38 inches. In general, however, this table shows the variation in rainfall in different sections. Some sections like Houma were favored with considerably more rain than other parts of the state. Other sections received practically no rain during the months of July, August, September and October.

TABLE 2

RAINFALL IN SUGAR BELT IN 1924. INCHES

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
Baton Rouge	8.98	5.00	3.76	4.68	2.91	3.35	0.55	3.25	0.00	0.07
Cinclare	7.95	4.98	3.60	4.71	3.53	3.44	0.57	1.38	0.05	0.04
Delta Farms	5.52	7.10	1.49	1.79	6.73	3.66	4.63	1.80	1.00	2.07
Donaldsonville	8.13	4.91	2.47	2.75	4.76	3.19	1.40	3.72	0.41	0.08
Franklin	8.19	7.67	2.07	4.37	8.70	6.68	3.22	1.84	0.99	0.00
Houma	6.41	6.90	1.63	1.84	5.20	4.49	2.74	3.43	3.97	0.43
Reserve	3.55	4.95	2.48			4.01	0.40	2.02	0.97	0.00
Abbeville	7.63	4.88	2.18	4.73	3.37	7.78	2.52	2.50	1.58	0.00
Alexandria	6.06	5.09	6.90	5.40	3.41	1.35	0.93	0.77	4.05	0.00
Lafayette	8.73	4.15	2.13	4.07	2.57	3.97	2.05	2.69	0.67	0.00
New Iberia	8.72	5.36	3.39	3.97	4.87	2.59	1.93	1.82	1.72	T
Angola	7.33	3.19	3.66	4.25	2.56	0.86	3.33	2.92	2.88	0.00

What effect have these drought conditions had upon the crops in the sugar belt? If the rainfall of the various localities is compared with the crop condition of November 1 as given on a previous page, it is seen that there is a very close relation between rainfall and crop conditions. East Baton Rouge with a crop condition of 18 per cent, Lafayette with 23 and St. Landry with 24 are all in localities with the scantiest rainfall, while Terrebonne represented by Houma records, with more rain had a crop condition of 55 per cent. Even if there had been no diseases or insects present and the soil had been in the best of shape, a satisfactory sugar crop could not have been raised under the drought conditions experienced in 1924. Evidently, then, the rainfall conditions must be considered as very important factors and responsible to a considerable extent for the poor crops of recent years.

Another weather condition must be mentioned though its influence on the crop conditions is not clear. The winter of 1923-24 was exceptionally cold. The following low temperatures in January were reported to the Weather Bureau: Angola, 11°; Baton Rouge, 15°; Houma, 16°; Franklin, 18°; Lafayette, 17°. With the cane lying in a watersoaked soil, it is possible that these low temperatures had an influence on the poor germination in the spring.

Cultivation, Drainage and Fertilization Conditions

For a number of years, the average cultivation and drainage conditions in Louisiana have not been held at the normal. Labor and climatic conditions have prevented proper cultivation and have held back the proper drainage work.

During the war and for some time afterward, labor was scarce and high priced. As a result, cultivation was often slighted or not done at the proper time. During 1923, climatic conditions prevented proper cultivation and drainage work. For weeks at a time, it was impossible to do anything in the fields on account of the continued rains. The fields became grassy and the soils packed.

As a result with the opening of the year, 1924, the soil generally was in an unsatisfactory condition. In digging up poorly growing plants during the summer of 1924, it was the usual thing to find the soil very firmly packed under the plants. Often the roots were confined entirely to the upper few inches of soil that had been stirred by the cultivator. They seemed unable to penetrate the hard ground below.

The soil remained practically saturated through a considerable portion of 1923. It was not uncommon to see the rows full of water over considerable areas and for considerable periods. Possibly no reasonable system of drainage would have been satisfactory under such moisture conditions. Yet it must be borne in mind that a saturated soil is not suitable for root development and is very favorable for the spread of root parasites. Many fields in 1924 showed very plainly the effect of unsatisfactory drainage conditions in 1923.

The effect of drainage has been brought out recently in an article by Mr. John M. Caffery (3). From results obtained on Columbia plantation, the depth of the drainage ditch has a considerable influence on the yield of both plant and stubble cane. A deeper ditch gave a considerably higher yield.

It has been suggested that the Louisiana soils are becoming depleted of the necessary plant requirements and that they are not now capable of producing the crops of former years; in other words, the fertilizers ordinarily applied have not been sufficient to keep the soils in a productive condition. As a matter of fact, there is no evidence that this is the case. Some fields have been allowed to run down and without doubt are not producing what they should but there is no evidence that they could not be brought back in a reasonable time. Depletion of soils and an unsatisfactory condition due to improper treatment are two different things. There is no question but what those fields with a good humus content which was produced by plowing under the cowpea and Melilotus crops, withstood the dry season of 1924 better than did the fields that had the cowpeas removed for hay as the soils with the humus held the moisture better than did those without.

The various field practices mentioned above, including cultivation, drainage and fertilization, have had some influence on the crop conditions of the past two years. They have without doubt been partially responsible for some of the differences observed in various localities. There is little question that a more general practice of plowing under legumes and more attention paid to the drainage conditions would raise very materially the tonnage of the Louisiana sugar crop. However, it is not believed that these are the most important factors in the present crop conditions.

Cane Borer Infestation

The cane borer has had its influence on the Louisiana sugar crops for many years. In some years, it has been more troublesome than in others. In 1923, there was a very heavy infestation. In some localities, in the fall of that year, it was difficult to find a stalk without a borer hole. In 1924, however, there was a comparatively light infestation. Not until late in the season did the borers begin to increase rapidly.

The borer, besides decreasing the weight of the cane and making the fibre content higher, permits the entrance of the red-rot disease. In 1923, the red-rot disease was extremely prevalent and this was in a degree made possible by the borer. While the borer was partially responsible for the poor stands of 1924, it could have had no influence on the growth of the crop during the summer.

The Diseases of Cane

The various diseases of cane have had a considerable influence on the present cane condition in Louisiana. There are three distinct diseases which should be kept in mind, these being the red-rot, the root-rot and the mosaic. These diseases have been under observation by the Experiment Station during a period of years.

The Red Rot

The red-rot is a disease which has been in Louisiana for a long period. It was first reported in 1910 (6, 7) but had doubtless been here for a long time previous to that date. It came under observation following a condition somewhat similar to the one in the state in the spring of 1924. The cane germinated poorly and came up to a thin stand. In order to ascertain the cause the Plant Pathology department of the Experiment Station obtained canes that failed to germinate from many of the sugar parishes. It was found that a very considerable percentage of the stalks was affected with the red-rot disease.

Red-rot is a disease that is known in many of the sugar producing countries. In some places, it does considerable damage while in other countries it does not seem to be so important. In India, it is apparently the most important of the sugar-cane diseases.

The red-rot is a disease confined largely to the inside of the stalk and consequently it is not readily recognized in standing cane. It is best seen when the cane is cut for planting or for the mill. If an affected stalk is split open, the disease shows to the best advantage. The inside of the stalk has red areas with elongated white spots running transversely across the red (Fig. 1). These white spots always show the presence of the red-rot and they make it easy to distinguish the disease. Any borer channel or other injury in a cane stalk will be surrounded by red tissue but unless the red-rot is present, there will not be any white spots within the discolored portion.

The fungus causing the red-rot enters a stalk either through a wound such as a borer hole or through the root buds on the nodes. All stalks infested with the borers are of course not affected with red-rot. The percentage of bored stalks infected with red-rot varies considerably in different years and in different fields. Fields have been seen in which fifty per cent of the bored stalks were also infected with red-rot but this is higher than ordinary.

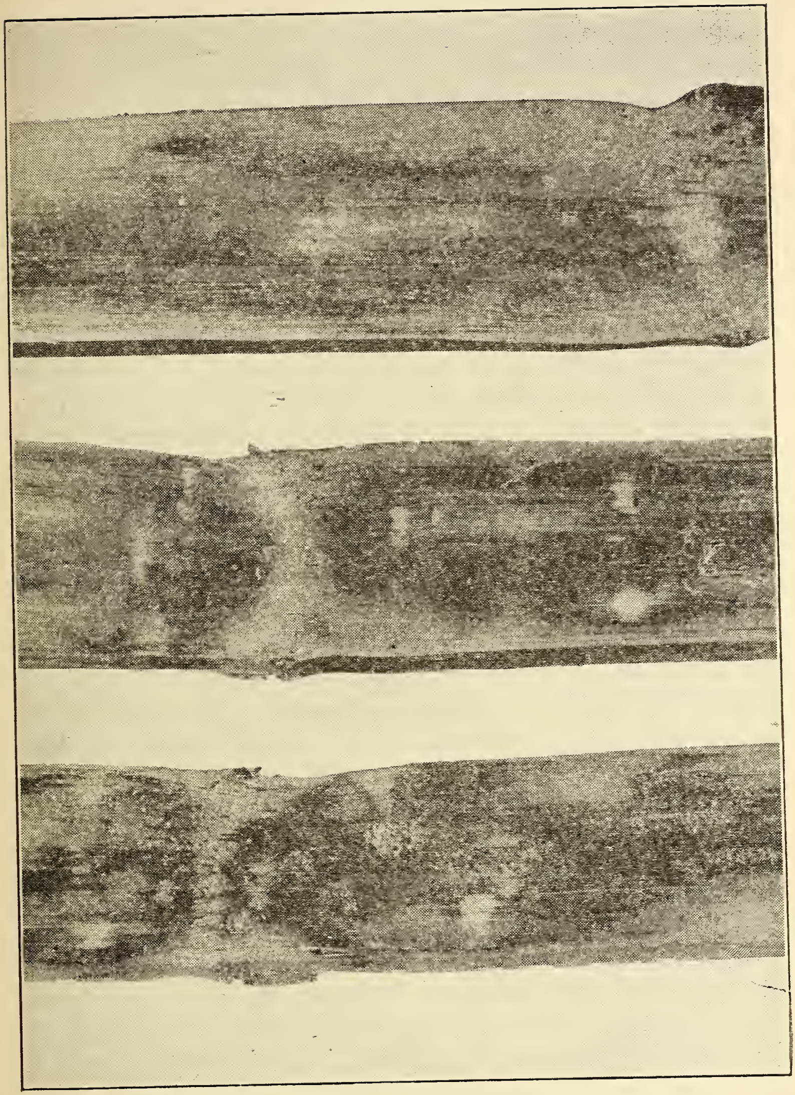

Fig. 1. Red-rot in split stalks of sugar cane. Notice the elongated white spots which are characteristic of this disease. From the crop of 1923.

The effect of red-rot is to reduce the sucrose content of the growing cane and to decrease the germination of the cane that is planted. Since the discovery of the disease in Louisiana, the Experiment Station has carried on rather extensive investigations with it and the results have been published in several bulletins (7, 8, 11).

The decrease in sucrose of the growing cane due to red-rot varies considerably depending on how early the cane becomes infected. If a stalk becomes infected while it is quite small, a very large per cent of the sucrose is used up by the fungus; if the infection takes place later in the summer, the decrease will not be so great. On an average, infected stalks will show a juice analysis of around 25 per cent less sucrose than uninfected stalks. If the number of stalks infected in a field is small, the total loss will be small; but if the percentage of infection runs high, the sucrose content of the juice at the mill will be appreciably lower.

As to the effect on germination, the red-rot becomes an important factor. Stalks affected with red rot germinate very poorly and this is one of the reasons for the low germination in the state. The average germination of the eyes in Louisiana is about 20 per cent. In order to obtain good stands, the Louisiana planter is compelled to use considerably more seed than is used in the tropics. While there are factors other than the red-rot concerned in the poor germination, it has been demonstrated that red-rot cane germinates much poorer than healthy cane. All that is necessary to obtain a thin stand is to inoculate the planted stalks with red rot.

In the season of 1923, the red-rot infection was as high as it has ever been seen in Louisiana. The very wet season combined with the heavy borer infestation made conditions ideal for the spread of the disease. Examinations made at the mills at grinding time showed this disease in great abundance. This very heavy red-rot infestation was one of the causes of the very low sucrose content of the juice in 1923.

This very heavy red-rot infection was also partly responsible for the very poor stands obtained in the spring of 1924. Trips were made over a greater portion of the sugar belt during the early part of the season. Hundreds of the old seed stalks which failed to germinate were dug up and examined. The percentage of these stalks showing typical red-rot was very large, apparently 75 per cent or more. Furthermore, on digging up the old stubbles that failed to grow, the same condition was found. These were just as severely infected with the red-rot as were the planted stalks. As it has been demonstrated that red-rot will cause just such a decrease in germination, the presence of such a heavy infection explains very largely the poor, thin stands of 1924.

Notwithstanding the fact that the spring started with a very heavy red-rot infection, there was very little spread of the disease in the growing cane during the season of 1924. This is easily accounted for by the very dry season which prevented the development and spread of the red-rot fungus and by the light borer infestation during the early summer months. Consequently at the end of the season there was very little red-rot. The very high sucrose analyses that were obtained at the mills would not have been possible with a heavy red-rot infection.

The cane used for seed in the fall of 1924 was exceptionally good on account of its freedom of the red-rot. The seed that was planted in soil containing sufficient moisture germinated extremely well. Some fields planted with selected cane were showing germinations of 70 and 80 per cent. However, red-rot was not entirely absent. In one field in which the seed was planted in early October in soil too dry for germination, out of approximately forty stalks examined on November 11, three showed the red-rot. Very little of the cane in this field was germinating but this was due to the fact that the stalks were drying and deteriorating from lack of moisture and not due to an excessive amount of red-rot.

The Mosaic Disease

The mosaic is a disease which has been in Louisiana for a period of approximately ten years. It was first reported in the United States by the senior writer of this bulletin in June, 1919, (9), following the receipt of a letter from Porto Rico in which it was stated that cane received from Louisiana had developed the disease. The disease had been seen for several years previously in Louisiana but had not been connected with the then little known mosaic disease on account of the apparently small damage it was doing. As a circular was later published by the Extension Division (10) and a bulletin by the United States Department of Agriculture (2), the planters have had the opportunity to become acquainted with the disease.

How the disease was introduced into the United States is not known. For many years, cane has been imported from various parts of the tropics by the Louisiana Sugar Station, by the United States Department of Agriculture and by numerous planters in the Gulf States. There was abundant opportunity for the disease to be introduced. The only surprising thing is that is was not introduced into the United States earlier than it was. When the disease was first recognized in the United States, there were centers of heavy infection in the river district of Louisiana and in areas in Georgia and Florida. The United States Department of Agriculture made surveys in Louisiana in 1919 and 1920. There was then but little of the disease west of the Atchafalaya river and only a small amount in the upper Bayou Lafourche district. In 1921, the Louisiana Experiment Station made a survey in the Bayou Teche district. Late in the summer of 1921, there was a five to ten per cent infection at Houma, a very small infection at Franklin, an occasional plant in a few fields at Jeanerette and practically none west of that. The disease has been spreading rapidly and in the time since has spread over the whole sugar belt. However, in 1924, the infection in the western part of the state had not reached the 100 per cent mark.

The mosaic disease produces a mottling or striping of the leaves, a condition which has become familiar to most planters. The stripes are lighter in color than the normal leaf. Affected leaves as a result are often distinctly paler than healthy ones. Destroying the green coloring matter in the leaves prevents the plant from functioning normally in its manufacture of food material.

The effect of mosaic is to retard the growth of the plant, or in other words, to reduce the tonnage. Unlike the red-rot disease, it has no influence on the sucrose content of the juice. Juice from affected plants will analyse at the mill just as well as from healthy plants.

How much loss the mosaic causes is a question. It is difficult to conduct a satisfactory test. For a test to be satisfactory, healthy and diseased seed cane should be planted side by side under similar conditions. If this is attempted, a greater portion of the healthy cane will be diseased before the year is over. Futhermore, for a satisfactory test, the healthy and diseased cane used for planting should be taken from the same field. That seed from different fields may give markedly different yields is a fact well-known to most sugar men.

The literature from various sugar countries contains many estimates of mosaic losses. While some of these are merely guesses, others are founded on tests of various kinds. These various estimates range all the way from about 5 per cent up to nearly 100 per cent. The most popular estimates found in the literature seem to be 30 to 40 per cent.

Loss estimates have been attempted in Louisiana in three different ways.

(1) Healthy cane from out in the state has been brought to Audubon Park and planted by the side of diseased cane which had been grown at the Experiment Station. These tests gave very variable results, some times the outside cane producing more and sometimes less than the Station cane. There are so many variable factors in such an experiment, including the vigor of the cane, the

stands obtained, the presence of other diseases, etc., that the results are unreliable and of little value.

(2) Healthy and diseased seed of the L 511 variety has been selected from the same field and planted under the same conditions. While this variety is subject to the disease, it is more resistant to infection and the disease spreads but very slowly during the season. Reliable data have been obtained with this variety. In three successive years the decreased yield from the infected seed was about 10 per cent.

(3) Canes of the D 74 and Purple varieties showing very little effect of the disease have been selected and planted by the side of diseased stalks of the same varieties and from the same fields. Gains from the selected seed have ranged from 8 to 35 per cent but other factors also enter here. The selected cane usually showed a greater freedom of root rot and other troubles also.

With the ordinary varieties, it is doubtful if the mosaic produces a loss greater than 10 per cent in Louisiana. Varieties show a great difference in regard to mosaic. Many of the seedlings and tropical varieties which have been grown at the Sugar Station are injured very severely by the disease but varieties like the D 74 show a considerable amount of tolerance. While a loss of 10 per cent makes the disease an important factor, it is evident it is not the only factor in the present short crop.

There is a statement found frequently repeated in articles on sugar cane mosaic which is not entirely justified from the observations made in Louisiana. It is said that infected cane deteriorates from year to year. By this is meant that the disease produces a slight loss the first year, a somewhat greater loss the second year, a still greater loss the third year, and so on. If this were so, there should be a comparatively light loss in the western part of the state and a very heavy loss in the eastern part at the present time. In sections like Reserve, the disease has been present for a number of years as this is one of the oldest centers of infection in the state, while in districts like Lafayette the mosaic is just becoming firmly established. If the loss from the disease increases from year to year, the condition of the cane should be worse at Reserve. As a matter of fact, the reverse was true. The cane at Reserve this year, in spite of the fact that there was practically no rain after June, was considerably better than in the Lafayette district. This is also shown by the November 1 crop report. St. John with 47 per cent and St. Charles with 60 per cent shows a considerable better condition than Lafayette with 23 per cent.

Futhermore, from very extended observations, there was no evidence to show that the loss from mosaic in 1924 was any greater on the old infected plantations than on those on which the disease had just become firmly established. As a matter of fact, there is some evidence that it was not so severe. In the seed-selection work conducted by the Experiment Station, it was apparently easier to find canes showing moderate or no loss from the disease in the old infected districts than in the newly infected ones. In the latter, the infected cane looked very much the same. This is a point, however, which must receive further attention.

Usually in Louisiana, only a single stubble crop is produced, and this differs from many of the tropical countries in which the crop is ratooned for many years. Consequently, there are no data in Louisiana on the effect of the mosaic on successive ratoon or stubble crops. The statements in the paragraphs above refer to new seed cane that has carried the mosaic infection for a number of years.

Root-Rot

The trouble commonly called root-rot or root disease has without question been an important factor in the crop yields of 1923 and 1924, especially in the latter year. This is not a new trouble or even a new development in Louisiana. It has been known in the state for a long period and has caused losses in certain years or on certain places when the environmental conditions were favorable. Root-rot is one of the old problems of the sugar industry. It occurs in practically every cane country, and in many, if not in most, it is the most troublesome of the cane diseases. Java, West

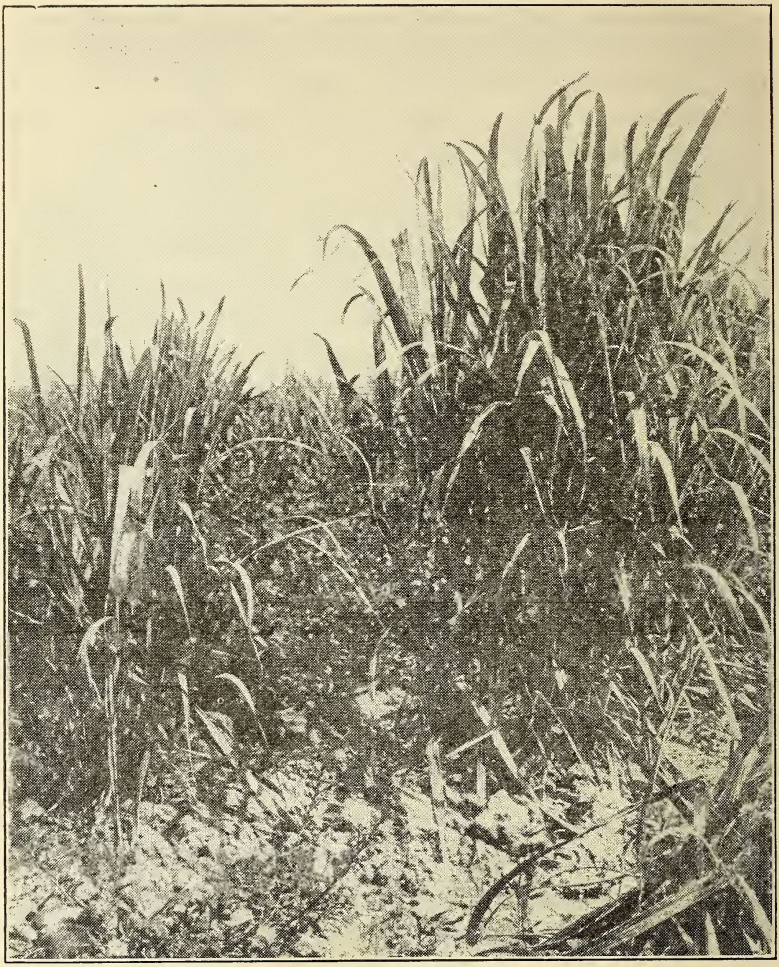

Fig. 2. A root-rot infected stool and a healthy stool of D. 74 cane growing side by side.

Indies, Hawaii and practically every other country as well as Louisiana, have had their root-rot difficulties.

The characteristics of root-rot vary to a considerable extent. In general, the affected plants grow slowly, often have a yellow color and usually stool poorly in the early part of the season, though in the latter part of the season there may be considerable suckering. In dry seasons particularly, the growth may be so slow that very few stalks of commercial value are produced. The roots show dead areas or sometimes are so badly rotted away that a whole stool can be pulled up with very little difficulty. Usually, also, the lower leaf sheaths of the affected stalks are cemented together by a white mold or mycelium though this is not always the case.

A dying of the upper leaves accompanied by a discoloration and rotting of the growing bud occurs also in severe outbreaks of root-rot. This characteristic of the disease is apparently the same as has been described from Australia as top-rot (17). There was considerable of this top-rot in certain sections of Louisiana in 1924, especially in the regions with the scantiest rainfall.

The effect of root-rot is more striking in a dry year than in a wet one, due to the fact that a plant with even a poor root system can absorb sufficient water from a wet soil to continue growth but it is unable to do so in a dry soil.

From the nature of root-rot, it is evident that it can be brought about by anything which causes the roots to decay or prevents their development. At various times in the past, a number of different organisms have been held responsible for this disease and it is possible, and even probable that a number of these play a part in its development under varying environment conditions. Among the organisms which have been reported in connection with root-rot, the following should be mentioned.

(1) Species of Marasmius. The Marasmius species are the ones which produce the white mycelium that cements the leaf sheaths together. These were about the first organisms associated with root-rot and for a considerable

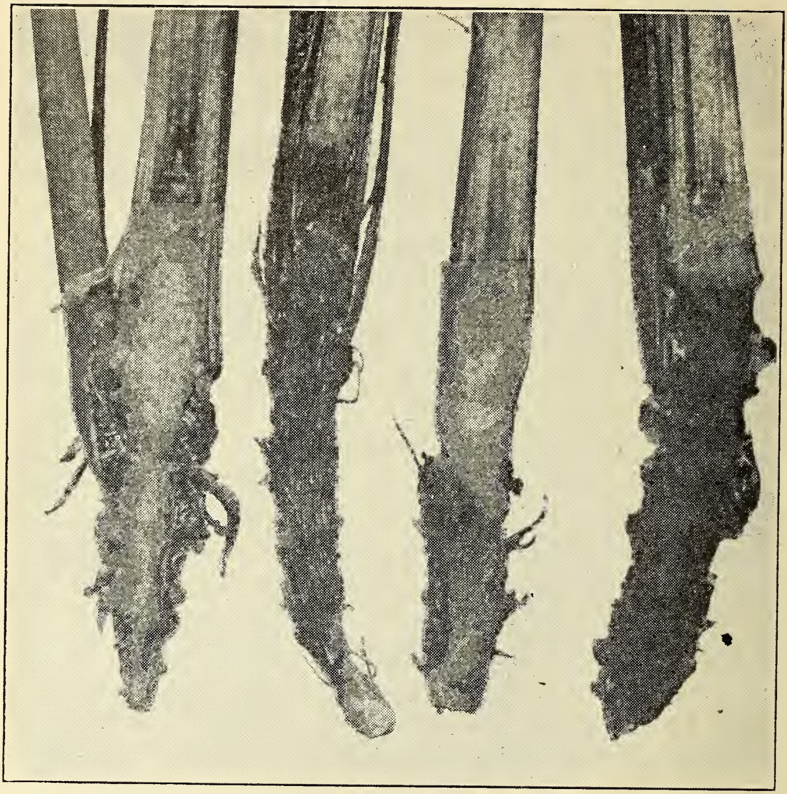

Fig. 3. Root-rot on young stalks that were still connected to the seed stalks. Notice the decayed area on the outside and the lack of roots. This has been called the "acute" stage of root-rot.

time were the only ones thought to be responsible. Later, when these organisms were found to be less parasitic than was at first thought, a number of workers went to the other extreme and stated that Marasmius had nothing to do with the disease. However, it is not unlikely, when the true relationship of the different organisms has been carefully determined, that the Marasmius species will find some place in the root-rot problem. It is often the tendency with the development of a new idea to throw aside the old one.

(2) Species of Pythium. Certain Pythium species have been reported from Hawaii (4) and some other tropical countries in connection with root-rot. It is the belief that some of these are of considerable importance in certain countries.

(3) Species of Rhizoctonia. Several Rhizoctonia species have been reported from Porto Rico (5, 13, 14) and Barbados (1) in connection with root-rot and evidence has been presented showing that they are important organisms in the West Indies. These organisms are also very abundant on cane roots in Louisiana.

(4) Snails. In a recent article, Rands (16) has shown that snails eat holes in sugar cane roots and he claims that roots injured in this way are more subject to root-rot. It is hoped that Dr. Rands can continue his work and ascertain more fully what effect the snails have on cane growth. There is no question that injuries such as he describes are abundant on many cane roots.

It is worth while to discuss the relation of these various organisms in connection with the 1924 root-rot epidemic in Louisiana. The root-rot was studied through the whole season, from early in the spring until late in the fall.

In the spring, a condition existed which largely disappeared as the season advanced. In May and June, many young cane plants died. On examination it was found that the basal portion of the young plant, from the point of attachment to the mother stalk or the old stubble to above the surface of the ground, was shrunken and had an area of dead and decayed tissue on the outside. Frequently this de-

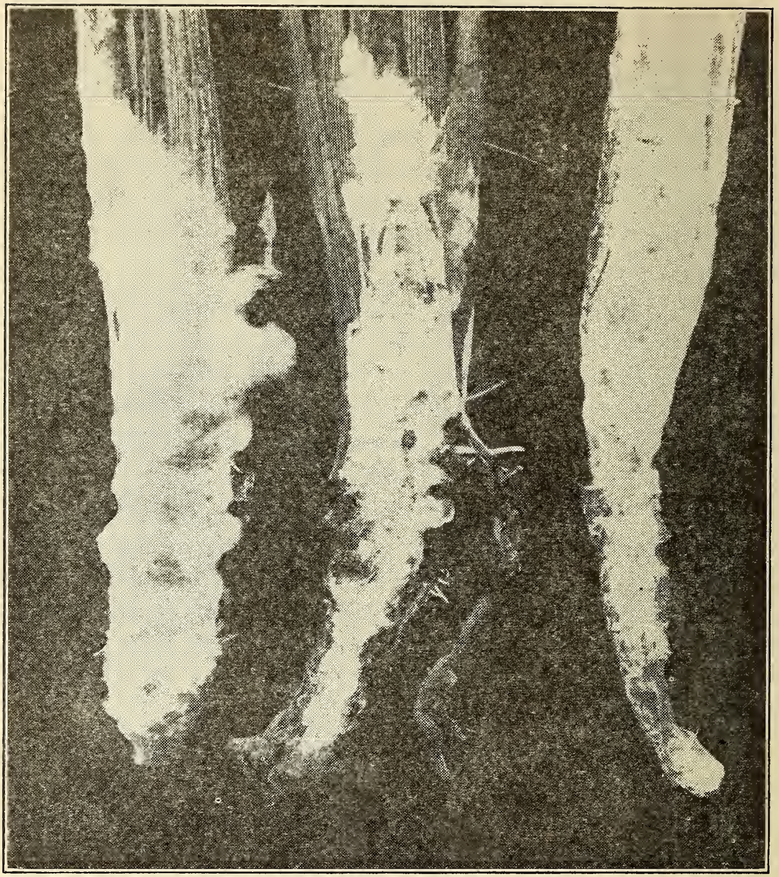

Fig. 4. The same stalks shown in figure 3 after thirty-six hours in a moist chamber. Out of the decayed areas has grown the mycelium of Marasmius.

cayed area extended entirely through the young stalk. This decayed area in every case examined was filled with Marasmius mycelium though it did not always show on the outside. When placed in a moist chamber, the dead area would become covered with a growth of the Marasmius mycelium. In figure 3 are shown some of these stalks as they came from the field split open to show the rotted areas; while in figure 4 are shown some of the same stalks after thirty-six hours in a moist chamber. This condition seems to be identical with what Nowell in a recent book (15) calls the "acute" stage of the root-rot disease. Such stalks were absolutely prevented from sending out any roots. This type of root-rot depleted the stands to a considerable extent in some sections. The Raceland section was seriously affected in this manner.

Later in the season, another type of the root disease developed. The proper number of young roots either did not form or as frequently happened, rotted after developing. The roots were red, often misshapen and usually showed lesions or rotted areas. In severe cases, the roots rotted back so that they were only stubs protruding from the stems, while in milder cases, they extended out for greater distances in the soil. In figure 6 are shown some roots characteristic of many cane fields in the state.

In culturing these affected roots, it was found that they did not contain a large number of different organisms. While a few saprophytic forms such as *Trichoderma lignorum, Oedocephalum echinulatum, Mucor sp.* and *Fusarium sp.* were very commonly present, it was found that a large percentage of the cultures also contained some of the Rhizoctonias which have previously been reported from the West Indies. A number of different species of Rhizoctonia were isolated from these roots. In the West Indies, these organisms are considered the most important of the cane root parasites.

It has been found that some of these Rhizoctonias are capable of producing root-rots very similar to the natural

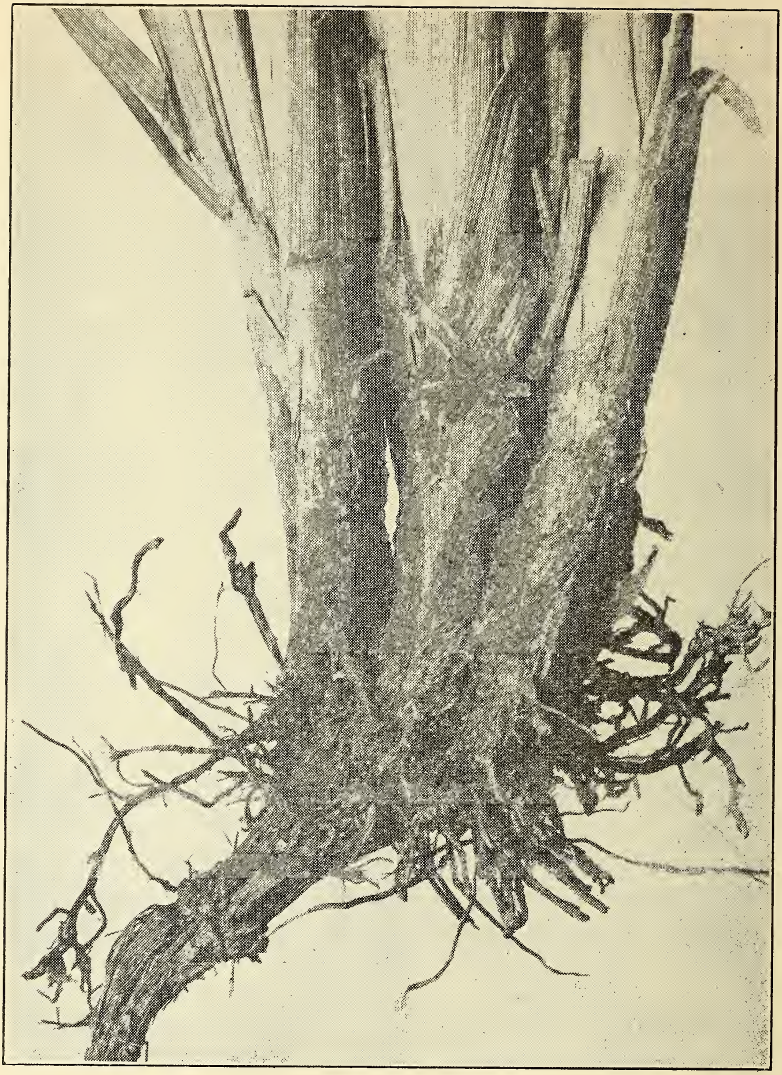

Fig. 5. A characteristic root-rot hill. The basal portion is rotted, the root system is very deficient and the lower leaf sheaths are cemented together by the Marasmius mycelium.

condition in the field. In figure 7 are shown roots affected with root-rot which was produced by artificial inoculation with one of these fungi. The illustration shows an upper joint from a healthy stalk which was sterilized for fifteen minutes in a 1-1000 corrosive sublimate solution and then placed in a pot of soil which had been sterilized in the autoclave under fifteen pounds pressure and then inoculated with a pure culture of one of the Rhizoctonias. The photograph was made thirty-one days after the stalk was planted in the inoculated soil. The affected roots on the right side show the same misshapen and stubby appearance as those occurring naturally in the field. The roots were red to brown in color like the naturally infected roots. The Rhizoctonia was easily reisolated from the discolored roots.

The effect of one of these Rhizoctonias is also shown in figure 8. These cane joints were sterilized with corrosive sublimate and placed in large sterile tubes containing wet cotton at the bottom. When the roots were pushed out, one tube was inoculated with Rhizoctonia while the other was left as a check. The photograph was made thirteen days after the inoculation. The misshapen, short and discolored roots of the inoculated stalk form a strong contrast with the healthy roots of the check.

Many other experiments have been run and are being run, not only with the Rhizoctonias, but with various other fungi found on cane. It is expected that a thorough study will be made of these organisms. For this general discussion of the disease situation, it is sufficient to say that the Rhizoctonias which are very common on cane are capable under favorable conditions of producing a root-rot similar to that found in the field in 1924.

All of these organisms which attack the cane roots are weak parasites. If the cane is growing rapidly, the roots are not as easily attacked by the parasites as are those on plants which lack vigor. Consequently, the factors which decrease the vitality of the plants also make them more susceptible to root-rot attack. Such factors include poor drain-

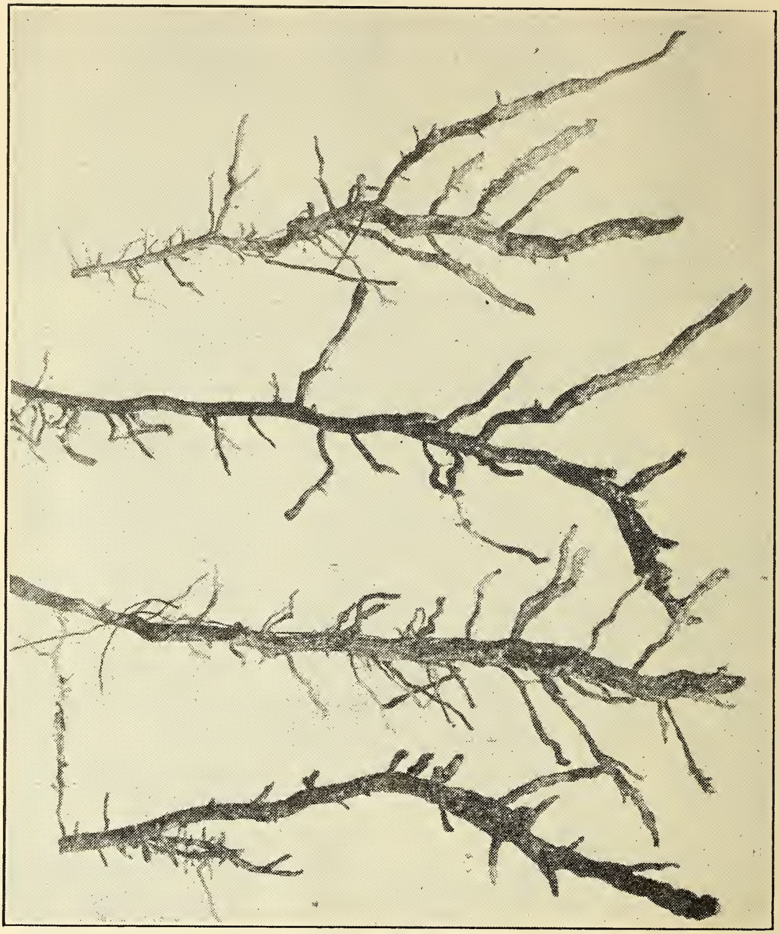

Fig. 6. Misshapen, stubby and discolored roots, common on cane affected with root-rot. From such roots, cultures of Rhizoctonia have been easily obtained.

age, poor cultivation, too much rain, a severe drought, too heavy a soil, presence of root-eating grubs, beetles, snails, etc., and the planting of weak or badly infected cane. During the seasons of 1923 and 1924, there has been a combination of these factors with the result that there was a very heavy infection of root-rot and a severe loss. The wet season of 1923 permitted the root parasites to develop abundantly and to accumulate in the soil and on the cane, while the dry season of 1924 was ideal for the development of the root-rot. Louisiana has suffered before with the root-rot and probably will again but it is very unlikely that such a combination of unfavorable growing conditions will occur very often.

Root-rot has occurred quite generally over the sugar belt. It was much worse in some sections than in others due to variations in soil and growth conditions. The black soils were, of course, the most severely affected. These black soils, however, are nearly always affected. Even in very favorable years, the tonnage in these soils is reduced very heavily by the root-rot.

Conclusions as to Cause

From the above outline of the climatic conditions, the soil conditions and the diseases present, there can hardly be a question that all of these have had their influence on the cane yields. The weather and soil conditions have been ideal for development and spread of the red-rot and the root-rot. It is not possible to say just what percentage of the loss has been caused by the weather conditions, by the borer, by the red-rot, by the mosaic or by the root-rot. It is evident that some of these have been greatly influenced by the others and that the general crop condition is due to the whole complex.

The Outlook

While there is no way of predicting a crop condition in the future, there are certain things which have a bearing on the crop of 1925 and those to follow which should be mentioned.

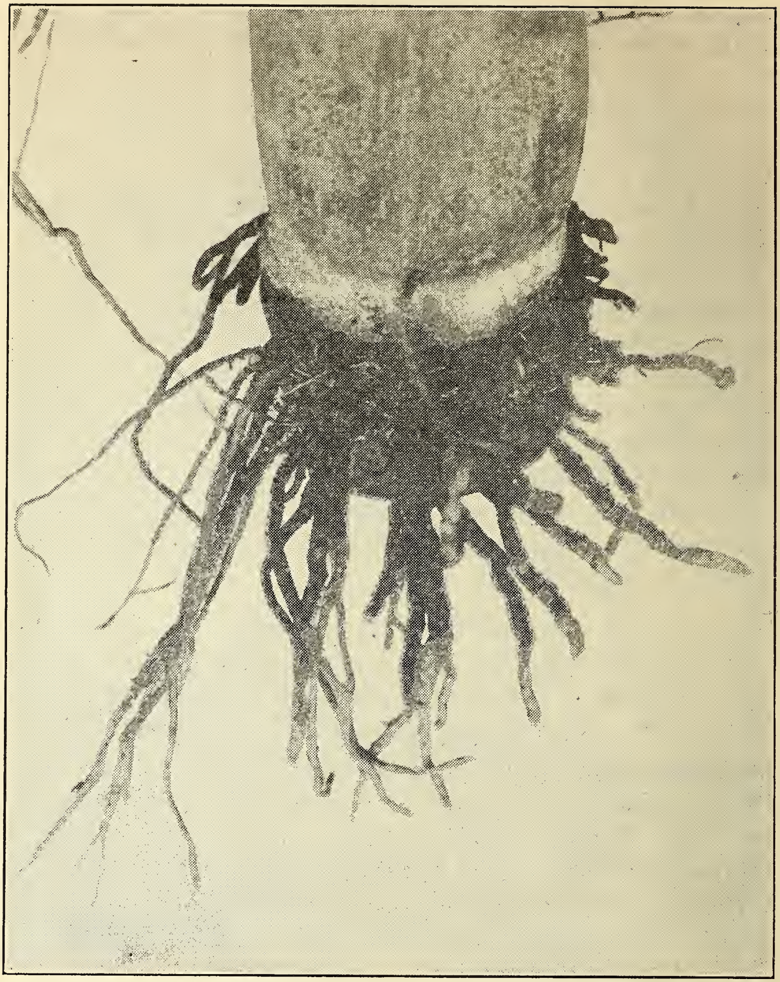

Fig. 7. Root-rot, following artificial inoculation. The stalk was sterilized with corrosive sublimate and planted in sterilized soil which had been inoculated with a pure culture of a Rhizoctonia. Photograph thirty-one days after inoculation. The misshapen and discolored roots should be compared with the naturally infected roots in figure 6.

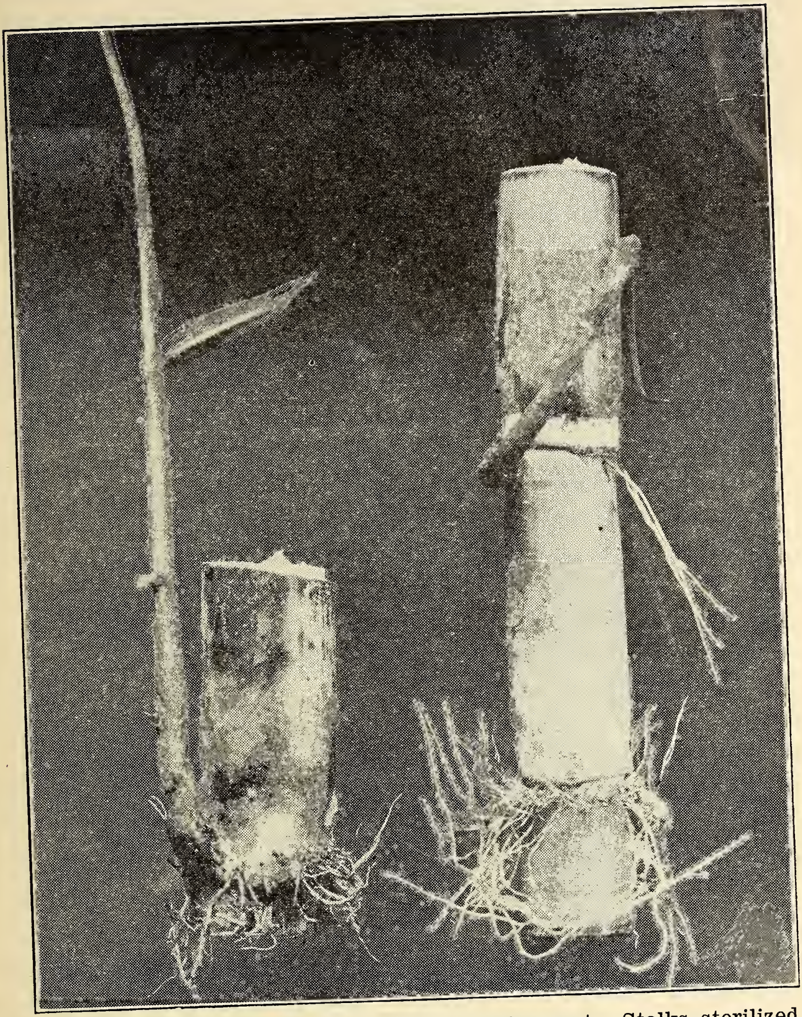

Fig. 8. Effect of Rhizoctonia on root development. Stalks sterilized with corrosive sublimate and placed in large sterile test tubes with wet cotton in bottom. Stalk on left inoculated with a pure culture of Rhizoctonia, stalk on right not inoculated. Thirteen days after inoculation.

(1) The seed used in the fall of 1924 was far superior to that of the preceding year. It was much less infected with red-rot and when planted in soil with sufficient moisture for growth showed a very high germination. As has been noted, some of this cane was showing a germination as high as 70 or 80 per cent in the fall. With such seed, the prospects for good stands and vigorous cane in the spring of 1925 are favorable.

The prospects for the seed which was planted early in a soil too dry for germination are not so good. Furthermore some of the cane that was pithy and hollow should be watched.

In general, however, it can be said that the seed situation is favorable.

(2) The soil condition in the fall of 1924 was in general better than for a number of years. The drying out of the soil has been a good thing for it. It has improved the physical condition and doubtless decreased the number of deleterious soil organisms which are common in wet, packed, sour soils. In some places, the dry condition has prevented a satisfactory preparation of the soil for planting but this is probably of less importance than the general improved condition.

(3) As a result of the activities of the Agricultural Committee of the American Sugar Cane League, a great interest has been aroused among the planters in regard to the importance of new varieties and the use of better seed. A very successful series of meetings, arranged by this Committee, was held by the Experiment Station and the Extension Division of the University in September and the large attendance was ample evidence of the general interest in this work. There is no question that this general interest has resulted in the planting of much better seed than formerly. The questions of new varieties and the value of seed selection will be treated in paragraphs to follow.

(4) With the approval of the Board of Supervisors of the University, the Experiment Station has entered upon a cooperative contract with the progressive and generous

owners of the plantations enumerated below, for conducting a series of carefully planned experiments, that will greatly facilitate the gathering of dependable observations on the behavior of new canes in different portions of the state and upon the sugar cane problems. By these agreements the Experiment Station furnishes the seedling canes, provides a specialist to visit the plats at proper intervals to make all needful notes on resistance to disease, etc., and will make all necessary chemical analyses, while the plantation owners cultivate the crop at their own expense, all in accord with a detailed plan approved by the Agricultural Committee of the American Sugar Cane League. These "Test Fields" are located as follows: On Glenwood Plantation, at Napoleonville; on Upper Ten Plantation, at Raceland; on Reserve Plantation, at Reserve; on Sterling Plantation, at Franklin; on Dr. Young's Plantation, at Youngsville, and on the Penitentiary farm at Angola. The work started in the fall of 1924 on these plantations included tests of new varieties, seed selection work, seed treatment work and fertilizer and rotation experiments.

P. O. J. and Other Seedlings.

During the season of 1924, there has been a great deal of interest aroused in regard to new varieties, especially the P. O. J. seedlings. The three capital letters adopted as a part of the name designate the origin of these canes. They are abbreviations of the three words that designate the Goverment Experiment Station of East Java. The ones which have been introduced into the United States and are now receiving the most attention, such as the P. O. J. 234, 213 and 36, are hybrids of one of the small Indian canes which are highly tolerant to mosaic and root-rot, crossed on some of the larger varieties. They are canes of rather small diameter and high fibre content, but are vigorous growers, more or less tolerant to mosaic and quite resistant to root-rot. Futhermore they germinate exceptionally well and the planting of one running stalk will usually give a good stand. This means a great saving in seed. These varieties were introduced into Argentina and have largely replaced the native canes there. They have also been introduced into Porto Rico and are promising well in that country. These canes have not been very pleasing to mill men in some of the tropical countries. The small size of the stalk and the clinging shucks also increase the harvest expense. In some of the tropical countries the harvest cost of some of the small canes like the Uba, is about twice as much per ton as with ordinary canes, but the high tonnage secured has compensated for these objections.

Most of the cane sugar experiment stations of the world have engaged in work along the line of importing varieties from other countries, and developing new seedling canes. The late lamented Dr. W. C. Stubbs, for many years Director of the Experiment Stations of Louisiana, took great interest in this work. Among the seedlings that he imported from Demarara are the now well known D 74 and D 95. The L 511 is a seedling produced at the Sugar Experiment Station, Audubon Park. Thousands of seedlings and many varieties more or less popular in other cane growing countries, were tested and discarded as not being any better than the standard canes now being cultivated.

When the Federal Horticultural Board instituted severe restrictions on importing canes and cane seeds into the Continental United States, our work along these lines was brought to a halt, as seeds and canes invariably died in quarantine.

In 1918, the Director of the Louisiana Experiment Stations, W. R. Dodson, requested the United States Department of Agriculture to undertake to germinate cane seeds, and to import cuttings of promising seedlings and new varieties, and grow them at Washington, D. C., until they could meet the quarantine regulations, and then send them to Louisiana. The following quotation is made from a letter under date of December 27th, 1918, addressed to United States Senator, Edward J. Gay, which explains the status of affairs at that time:

"With the results thus far attained, I think we can not afford to give up the propagation of seedling canes, and yet, with the difficulty of securing good seed, it seems like it will be practically impossible for us to comply with the requirements of the Federal Horticultural Board and still get seedlings that will germinate. The delays in getting the seedlings through the Inspection Service cause them to lose their vitality, if indeed they are not destroyed by the fumigation process to which they are subjected.

"There has been a good deal of correspondence between Mr. Taggart, of the Sugar Experiment Station and the Federal Horticultural Board, regarding this matter, and the correspondence has not been very satisfactory to us. I want to now try another way of securing seedlings without setting aside any of the regulations or requirements of the Federal Horticultural Board, and this is, to have the Department of Agriculture germinate the seeds that may be imported and then send us the cuttings from the greenhouses at Washington.

"With all of the money spent for the introduction of valuable plants, it seems to me that it would be a small consideration for the Department to give to the sugar planters, to germinate a good number of seedlings each year and send the first cuttings to the Station at Audubon Park each year, for field test. Can't you take this matter up and see what arrangements can be made for accomplishing this end? It will soon be time to secure seeds from the tropics and there ought not to be any time lost if we are going to get a crop of seedlings this year.

"Our correspondence has been mainly with Mr. Peter Bisset, of the Bureau of Plant Industry, though I suggest that you might find Dr. B. T. Galloway, Plant Pathologist of the Bureau of Plant Industry, Foreign Seed and Plant Introduction, a valuable man to communicate with you.

"Very respectfully,
(Signed) W. R. DODSON, Director."

Senator Gay took a very active interest in this matter, and early in 1919, at his request, Mr. Dodson made a special trip to Washington, D. C., to attend a conference with Dr. W. A. Taylor, Chief of the Bureau of Plant Industry, Dr. B. T. Galloway, Pathologist of the Foreign Seed and Plant

Introduction Division, Dr. L. O. Howard, Chief of the Bureau of Entomology, and United States Senator Edward J. Gay, to discuss the plan of securing seedling canes.

The U. S. Department of Agriculture had already started some sugar cane work in 1918 because of the serious situation in Porto Rico and the representatives of that Department agreed to enlarge the work as funds were available. As a result Senator Gay agreed to urge an appropriation to take care of the work. He faithfully carried out his promise, enlisting the aid of other Louisiana representatives in Congress and that of representatives from other states, engaged in the production of sugar cane syrup, and together they secured the desired appropriations.

The Department worked out its owns plans for propagating these canes in Florida at Canal Point, and the plans for the work have been enlarged as rapidly as available funds would permit.

It was just at this time that some of the P. O. J. seedlings were beginning to be promising in certain of the sugar producing countries. The Louisiana Experiment Station attempted to secure importation of these seedlings, and arranged with the Director of the Experiment Station of Argentina to ship several barrels to the Federal Horticultural Board, Washington, D. C., for use in Louisiana. This shipment was found to be infected with mosaic and was destroyed. The Bureau of Plant Industry thereafter took the initiative in importing seeds and seedlings and imported a number of P. O. J. seedlings directly from Java. These were grown at Canal Point, Florida, and later shipped to Louisiana. The Louisiana Experiment Station has since made no attempt to bring in cane from without the borders of the United States. It is considered as unsafe to import any considerable quantity of any cuttings, and importations of the U. S. Department of Agriculture have been restricted to small pieces of cane that could be minutely examined and grown under quarantine in the greenhouses in Washington, D. C., for a year. We believe that this policy has been on the side of safety and that the Federal Horticultural Board has acted wisely in not taking any chances on importing any new diseases or insect pests into this country, through sugar canes.

The first seedlings received by the Sugar Experiment Station, from the Department, were obtained in March, 1922, and we have received up to this time approximately 2500 seedlings. Out of this number we have something like 20 that are quite promising, as being highly tolerant to the diseases that are prevalent in the State and showing good tonnage and high sucrose content. There are probably 200 that are worthy of further cultivation and observation.

The Bureau of Plant Industry of the U. S. Department of Agriculture, and the Louisiana Experiment Stations, are now working under a memorandum of agreement, recently formulated, that defines our relations so clearly in the cooperation, that there should be the most cordial and effective relationship in this work.

The Bureau is to investigate sources of promising new seedlings and varieties, in foreign countries, bring them to Washington, D. C., and keep them for a year, under observation in a sugar cane quarantine greenhouse at Arlington farm, and then send those that show freedom from disease and insect pests to the field stations of the Bureau of Plant Industry and to the Louisiana Station. They will continue their work of producing and germinating sugar-cane seeds at Canal Point, Fla., and send cuttings of all promising seedlings to the Louisiana Stations and also send seeds when a surplus of seeds of desirable crosses are available.

The Louisiana Station is to plant in test plots all seedlings and other varieties from the Bureau, and to make records of their susceptibility or resistance to disease, insect pests, etc., and on the rate and character of growth, make such chemical analyses as may seem necessary, etc. They will plant and cultivate all of these seedlings so long as they do not require an area to exceed twenty-five acres. The best of these seedlings will be grown in increase plots, for distribution to cane planters, until these plots occupy an area of not more than twenty-five additional acres. The Louisiana Station will also provide funds to the extent of $1,000 a year toward meeting the expenses of enlarging the seedling propagations, and preparation for shipment of canes to Louisiana from Florida.

The disposition of the products of the Experiment Station test fields at Baton Rouge and the field station of the Bureau of Plant Industry at Houma, La., will be made in accordance with plans approved by the Chief of the Bureau of Plant Industry and the Director of the Experiment Stations, annually. The Experiment Station and the Bureau will exchange notes and records on the behavior of these seedlings and varieties, annually, or oftener, if desirable. Both parties to the agreement will be free to publish data on the performance records of these canes, providing such results are credited to the cooperative work. This agreement was formulated and signed after a conference held at the request of the Director of the Louisiana Experiment Stations, and Dr. E. W. Brandes, in charge of the Sugar Investigations of the Bureau of Plant Industry, between W. A. Taylor, Chief of the Bureau of Plant Industry; Dr. B. T. Galloway of the Division of Foreign Seed and Plant Introduction; Dr. K. F. Kellerman, representing the Federal Horticultural Board; Dr. F. H. Chittenden, of the Bureau of Entomology; Dr. E. W. Brandes, in charge of Sugar Investigations; and W. R. Dodson, Director of the Experiment Stations, Louisiana.

All of the above named gentlemen are interested in the sugar cane situation in Louisiana, and want to do what they can to aid the work on seedling canes. More liberal appropriations of the Federal Government for the work of the Bureau on sugar cane seedlings at Washington and in Florida, and of State appropriations for the work at Baton Rouge, would increase the volume and probable value of this work.

At present there are only a few acres of the P. O. J. seedlings in Louisiana. They look promising in many ways. It may be that they will produce more than the D 74 and Purple canes ever did. That is really what happened in Porto Rico with the Uba variety. The Uba in Porto Rico outyielded the standard varieties even where the mosaic was not present. If the P. O. J. seedlings do the same in Louisiana, they may replace the D 74 and Purple canes, but as to this, only time will tell.

Seed Selection Work

As a possibility of bringing the cane industry back to normal, seed selection work has been advocated by the Experiment Station. It has been demonstrated by the selection work carried on at the Sugar Station over a four-year period that the tonnage can be materially increased and the amount of seed necessary for planting decreased. It has also been demonstrated that strains of D 74 and Purple can be selected which show a very marked resistance to mosaic. The strain of Purple which has been selected at the Station has held its resistance to the disease for three years though it has been growing in a field that showed a 100 per cent mosaic infection.

In the series of meetings held in September, two things were advocated in regard to the seed selection work.

(1) For the general planting, only good, healthy blocks of cane should be used for seed. All the poor, scrappy, root-rot infected cane should be sent to the mill. In former years, the poor diseased cane has been used for planting. Good crops have been produced from scrappy seed, yet the general use of such seed is a dangerous practice.

(2) Each planter should start a seed plot. For this the cane should be very carefully selected on the stool basis. Only stools showing at least four large stalks, an apparent freedom of root-rot and borers, and a tolerance to the mosaic should be used. The cane grown in the seed plot is to be used for propagation purposes the following year. By this stool selection, it is believed that the cane can be gradually relieved of the heavy root-rot infection.

During the fall of 1924, a considerable amount of stool selected cane was planted. Some planters selected only a small amount while others have fifteen to twenty acres or more. As there is selected cane in nearly every section, there will be an excellent opportunity in 1925 to compare this with the unselected cane and with the P. O. J. seedlings. The selected fields seen in the fall of 1924 were showing germination with a vigor that is very unusual.

From the tests that have been made at the Sugar Station, it is believed that the D 74 and Purple canes can be brought back to a profitable basis again. The D 74, Purple and other standard varieties, have been very valuable canes in Louisiana. They have been misused by the continual planting of the poorest and most diseased seed. This has permitted the gradual accumulation of the root organisms both in the soil and on the cane. These varieties should be given a chance to come back by careful selection work.

Whether the P. O. J. or other seedlings ultimately prove to be superior to the standard Louisiana canes or not, the crops of the next few years must be made with the latter varieties. It will take a number of years to sufficiently try out the new varieties and propagate them so that there will be sufficient seed for planting. Any improvement of these immediate crops is important. If the new seedlings are found superior, they will in time naturally take the place of the other canes; if not, then the selection work will mean a permanent improvement of the present varieties.

Summary

The sugar crops of 1923 and 1924 in Louisiana were very short. The 1924 crop was especially poor.

No single factor can be given as the cause of these poor crops. They were caused by a complex; including weather conditions; cultivation, drainage and fertilization conditions; cane borer infestation; and the attack of several diseases.

The season of 1923 was next to the wettest year on record, while 1924 was the driest. There was not sufficient moisture in most sections in 1924 to make a crop. The local variations in rainfall showed a marked effect on the crop in different sections.

The excessive rainfall of 1923 prevented proper cultivation and the drainage systems were not able to take care of the excessive amount of water. The soils remained watersoaked and were in a poor physical condition.

The cane borer infestation was heavy in 1923. This permitted a severe red-rot infection with the result that the seed cane used in the fall was very inferior.

Three diseases had their effect on the crop, the red-rot, the mosaic and the root-rot.

The red-rot decreased the sucrose content of the juice in 1923 and materially hurt the germination of the buds. This was one of the reasons of the thin stands in 1924.

The mosaic decreases the vigor of the cane and undoubtedly produces a considerable loss. The oldest infected districts, however, were not the ones showing the poorest crop conditions.

The root-rot aided by weather conditions, was very important. This showed up in practically every section of the state.

It has been demonstrated that the same fungi which are given as the cause of the root-rot in the West Indies were on the roots of the Louisiana canes. Furthermore the root-rot condition has been produced upon roots by artificial inoculation.

The seed cane used for planting in the fall of 1924 was superior to that of previous years.

The P. O. J. and some other seedlings which have been introduced into Louisiana show considerable promise but it will take several years to test them out and propagate enough seed for general planting.

The selection of healthy seed cane is advocated in order to gradually free the canes of the excessive root-rot infection and to reduce the loss from mosaic.

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W. R. DODSON, Dean and Director

BATON ROUGE, LOUISIANA

SUGAR BEETS IN LOUISIANA

BY
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FOREWORD

The results of the four years' work herein given on sugar beets are preliminary, and further investigations will be conducted. Larger acreages of the better varieties will be planted on different soil types so the economic problems can be more carefully considered.

New varieties will be given preliminary trials, at the same time, to attempt to find others that might produce a larger yield as well as a higher percentage of sucrose. Seed must be obtained from other sections as it has been impossible to grow seed in Louisiana. This condition may be a hindrance to constancy of results, or to improvement of plants, as breeding and selection to meet local conditions is practically eliminated.

If this crop should be suitable for commercial purposes, it will probably be better adapted to the small farm than to the large plantation. It is believed that a few acres grown by farmers within a distance of 40 to 50 miles of sugar mills can be more economically handled than larger areas.

Dr. W. C. Stubbs, for many years director of the Louisiana Experiment Station, started sugar beet investigational work at Kenner, Audubon Park and Baton Rouge. Dr. C. E. Coates[1] and others have continued this early work at Baton Rouge on bluff soils.

A large sum of money is invested in sugar houses and sugar house machinery by the sugar cane planters of Louisiana and is used only eight to twelve weeks in a year, as the grinding of the cane crop requires approximately that time. If this season could be lengthened eight to ten weeks by the utilization of a sugar-beet crop, the increased value of the sugar manufacturing machinery on Louisiana cane plantations would be considerable, as a comparatively small outlay would be necessary to equip the cane mills to handle beets. All the data hereafter given, unless otherwise designated, is from beets grown at Baton Rouge.

A planting of Vilmorin Improved beets was made November, 1898, and harvested the following May and June. The results of this first experiment will be found in Table 1.

TABLE 1.

Date of Planting—November, 1898.
Variety—Vilmorin Improved.

Date of Analysis	Average Weight of Beet—Grams	Sucrose %	Purity
May 2, 1899	600	9.89	73.00
May 3, 1899	870	8.13	74.30
May 15, 1899	1200	10.76	80.70
May 16, 1899	1980	8.59	74.10
May 31, 1899	1140	11.54	83.60
May 31, 1899	1500	9.49	76.50
June 6, 1899	960	12.61	91.30
June 6, 1899	930	14.96	90.60
June 10, 1899	600	12.64	89.70
June 10, 1899	1500	13.64	85.70
June 10, 1899	1080	11.99	91.50
June 10, 1899	1440	9.24	75.70
June 12, 1899	900	12.94	92.40
June 12, 1899	630	13.74	84.20
June 12, 1899	720	14.04	87.70
June 12, 1899	660	11.04	72.10
June 12, 1899	4560	8.14	70.70
June 12, 1899	2100	8.39	66.30
June 13, 1899	480	14.50	90.60

[1] Journal of Industrial and Engineering Chemistry. Vol. 14, No. 3, page 213.

A wide variation is shown in the size and the sugar content of the beets. Coates reports that the beets were not uniform in quality; the ones weighing from one to two pounds appeared to be normal sugar beets while the larger ones resembled the mangels and, as the data show, were low in sucrose. There is no doubt that the seed was not of uniform quality and probably not all of the same variety. This work was repeated in 1899 with practically the same results. No other work was done until 1904, when Coates made one planting of Vilmorin Improved and one of Kleinwanzleben. See Table 2.

TABLE 2.

Variety	Average Per Cent Sucrose			
	April	May	June	July
Kleinwanzleben	5.7	4.8	5.5	3.3
Vilmorin Improved	9.2	6.8	7.6	7.3

Here, again, Coates reports that the Kleinwanzleben were large and extremely low in sugar content. The Vilmorin Improved were smaller and more uniform as to size than in 1898 and 1899, but the per cent of sucrose was considerably lower.

Further plantings were made of these two varieties in August, 1907; November 26, 1907; January 30, 1908. Results given in Table 3.

TABLE 3.

Variety	Date of Planting	Average Per Cent Sucrose		
		February	April	May
Vilmorin Improved—	August, 1907	14.76	10.90	....
	November 26, 1907	....	8.50	11.00
	January 30, 1908	....	6.60	8.90
Kleinwanzleben—	August, 1907	12.88	9.70	....
	November 26, 1907	....	7.63	9.60
	January 30, 1908	....	6.13	7.90

The winter of 1907-08 was mild, the August planting maturing beets in February. All results were far from satisfactory and as seed cannot be produced in Louisiana, the work was discontinued until more promising varieties could be developed.

1920-1921

Nothing further was done until the fall of 1920, when a cooperative project was arranged whereby Coates was to do the chemical work and Kidder, the agricultural part. Seed of six varieties were obtained.

Variety	Source
Kleinwanzleben (Michigan grown)	Office of Sugar Investigations, Bureau of Plant Industry, Washington, D. C.
Alvarado (Michigan grown)	Office of Sugar Investigations, Bureau of Plant Industry, Washington, D. C.
Dippe (Michigan grown)	Office of Sugar Investigations, Bureau of Plant Industry, Washington, D. C.
Kleinwanzleben elite (German grown)	Office of Sugar Investigations, Bureau of Plant Industry, Washington, D. C.
Great Western Home Grown	The Great Western Sugar Co., Denver, Colorado.
Jaensch Victrix 12844	Utah Experiment Station, Logan.

These varieties were planted on January 24, 1921. The plat used was well drained and fairly rich in organic matter. The seed bed was well prepared and laid off in three-foot rows. No fertilizer was applied. The first beets for analyses were harvested May 9, 106 days after planting. Three beets were taken from each row once a week for the chemical work. Table 4 shows the data.

TABLE 4.

Date of Planting—January 24, 1921.

Variety.

Date Harvested for Analysis	Jaensch Victrix (12844)		Great Western Home Grown		Kleinwanzleben (Michigan)		Alvarado		Kleinwanzleben (Germany)		Dippe	
	Sucrose %	Purity	Sucrose %	Purity	Sucrose %	Purity	Sucrose %	Purity	Sucrose %	Purity	Sucrose %	Purity
May 9	13.0	82.6	14.6	83.7	14.0	85.9	13.5	84.5	13.4	85.9	13.7	84.9
May 16	13.2	83.3	13.8	84.6	13.0	85.5	13.4	85.5	13.5	85.4	14.0	84.8
May 23	14.0	82.5	15.1	83.3	14.5	83.5	14.9	85.5	14.2	84.6	14.5	84.5
May 30	13.8	89.0	15.0	87.8	14.1	85.5	15.1	87.7	12.5	79.6	14.8	87.9
June 6	12.6	80.0	13.8	79.9	12.4	84.1	13.5	81.1	13.6	80.9	13.1	80.1
June 13	12.2	80.1	14.4	86.7	13.2	88.8	12.5	85.5	12.4	79.1	13.3	85.0
June 20	14.5	84.5	14.7	82.6	13.8	83.3	15.9	86.0	14.8	84.6	16.8	87.0
June 27	13.3	86.4	14.1	81.0	14.6	86.0	14.8	85.2	15.7	88.2	13.5	84.5
July 4	12.9	83.7	14.2	83.3	13.3	82.7	13.4	81.2	12.7	83.0	13.6	82.2
July 11	12.6	82.5	12.9	82.9	12.6	82.1	12.8	81.5	12.1	82.9	12.7	82.6
July 18	10.8	79.1	12.3	82.3	12.9	83.4	12.2	81.4	12.5	80.6	12.9	84.3
July 25	10.9	78.5	12.4	82.2	13.5	86.1	10.6	73.4	11.9	80.2	12.6	83.8

The analyses were made within one or two days after harvesting. The sucrose content showed no great variation until the last two weeks, when the beets were of lower quality, probably due to over-ripeness. This season was extremely favorable for the crop, as warm rains hastened germination and light, warm showers, while the beets were young, contributed to rapid growth.

The beets were of uniform size. Table 5 shows the variation of weight in the above beets harvested for analytical data.

TABLE 5

Average Weight of Beet Analyzed—Grams

Date of Harvest	Jaensch Victrix 12844	Great Western Home Grown	Variety Kleinwanzleben	Alvarado	Kleinwanzleben elite	Dippe
May 9	440	385	420	440	340	480
May 16	420	520	530	480	665	470
May 23	475	540	675	610	745	515
May 30	675	615	560	630	585	505
June 6	595	750	610	565	725	635
June 13	760	815	850	780	1080	840
June 20	490	675	785	605	715	390
June 27	565	670	690	620	520	545
July 4	555	530	585	640	590	515
July 11	500	550	630	600	740	525
July 18	425	360	360	650	695	360
July 25	495	385	350	555	415	360

In sampling no attempt was made to select the beets, but they were taken, in most instances, as they came in the row. It was considered that this would give a fairer test than by taking them here and there in the rows.

The yield per acre was considered high. It is reported in Table 6.

TABLE 6

Calculated Yield per Acre—Tons

Variety					
Jaensch Victrix 12844	Great Western Home Grown	Kleinwanzleben	Alvarado	Kleinwanzleben elite	Dippe
17.5	19.2	19.7	19.8	20.9	17.2

A careful record of the labor required to prepare the seed bed and grow the beets was kept and calculated to the acre basis in man and horse hours. The man hours were 73.5 and horse hours 29. This low labor cost was due to the favorable season. In view of the fact that the beets are grown during the winter season, very few weeds will grow, which decreases the amount of hand labor. Usually one hoeing only is necessary which, together with the thinning, makes two times over the field with hand work. This leaves the bulk of the cultivation with horse-drawn tools, such as the five-tooth and the fourteen-tooth one-horse cultivators, together with a small middle-burster. This low cost of hand-labor production may prove of great value.

1921-1922

In 1921, seed of the same varieties and from the same sources was obtained as in 1920. The plat used for this purpose was planted in corn and velvet beans in 1920 and soy beans in 1921. As soon as the beans were harvested for hay, the plat was broken about eight inches deep with a 26-inch reversible disc plow and thoroughly disced. Rows three feet wide were laid off and seeding begun on November 27, and continued every four weeks until four plantings were made. Two duplications of each variety on each date were planted. A cold rain as the plants of the third seeding were coming through the ground, caused a considerable number to die though extra hand labor saved a fair stand. Other plantings came up to a good stand. The analytical data will be presented in Table 7.

TABLE 7

Date Harvested for Analysis	Kleinwanzleben (Michigan grown seed)								Great Western Home Grown								Jaensch Victrix 12844							
	Date of Planting								Date of Planting								Date of Planting							
	Nov. 27		Dec. 27		Jan. 23		Feb. 17		Nov. 27		Dec. 27		Jan. 23		Feb. 17		Nov. 27		Dec. 27		Jan. 23		Feb. 17	
	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity
May 1	14.1	83.6	...	...	...	...	...	...	13.4	81.2	...	...	...	...	...	...	12.7	81.0	...	...	...	...	...	...
May 8	11.6	83.5	11.7	77.4	11.0	79.2	...	...	14.3	87.2	11.7	83.4	11.7	79.2	...	...	12.5	81.7	11.4	81.3	11.1	79.6	...	...
May 15	14.5	83.8	14.0	84.8	12.4	80.0	...	...	14.7	82.5	13.0	81.2	12.5	81.8	...	...	13.3	82.6	13.2	84.7	13.0	77.8	...	...
May 22	14.8	85.7	13.4	83.8	13.0	83.4	11.7	83.5	15.0	84.4	13.8	84.7	14.4	86.7	11.3	80.8	14.7	85.0	13.4	83.8	13.5	84.7	11.1	81.6
May 29	14.9	86.8	13.7	88.8	12.0	83.5	12.0	83.7	13.4	83.2	13.3	85.2	14.6	88.9	12.0	85.1	13.5	83.5	11.8	81.4	12.7	85.2	12.2	83.1
June 5	14.4	87.9	15.0	91.0	13.9	88.6	13.5	88.2	15.0	90.5	13.0	86.7	15.0	90.1	13.3	86.8	14.6	92.0	13.9	89.5	14.1	87.8	12.8	83.7
June 12	13.9	87.1	12.4	86.3	14.4	92.2	11.5	85.9	15.5	89.0	12.7	86.4	13.0	85.0	12.0	88.3	13.3	90.0	12.5	85.8	13.2	87.2	13.2	88.2
June 19	13.6	82.8	12.4	83.6	12.7	83.6	13.1	81.7	11.4	80.1	14.8	87.0	12.4	83.8	12.7	82.7	14.0	87.0	12.7	81.0	11.6	83.7	12.7	83.0
June 26	11.7	81.9	12.2	80.6	12.0	83.8	11.8	81.4	13.3	83.5	12.1	83.7	12.3	81.6	12.1	81.3	12.3	84.2	12.0	82.1	11.5	79.4	11.3	80.2
July 3	12.0	82.1	12.7	84.6	12.7	83.6	12.7	83.7	12.5	82.5	12.3	84.8	12.5	84.5	13.3	85.3	9.4	76.5	12.0	82.7	11.2	81.4	12.6	84.5
July 10	10.6	80.0	11.9	82.1	13.0	81.3	12.5	82.1	12.7	83.7	11.6	81.7	12.9	81.5	12.0	81.6	10.5	80.7	11.4	80.7	11.9	80.5	11.5	81.0
July 17	...	...	...	...	10.9	79.7	9.0	75.4	...	...	...	...	11.7	81.7	12.0	81.6	...	...	...	...	10.2	77.7	10.5	79.0

TABLE 7—Continued

Date Harvested for Analysis	Dippe								Kleinwanzleben (German grown seed)								Alvarado							
	Date of Planting								Date of Planting								Date of Planting							
	Nov. 27		Dec. 27		Jan. 23		Feb. 17		Nov. 27		Dec. 27		Jan. 23		Feb. 17		Nov. 27		Dec. 27		Jan. 23		Feb. 17	
	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity	Per cent sucrose	Purity
May 1	14.1	86.5	...	...	...	...	...	...	14.1	84.0	...	...	...	...	...	...	13.9	84.3	...	...	...	...	...	..
May 8	12.8	83.5	11.7	78.0	10.0	72.0	...	...	13.1	84.5	12.0	82.8	11.5	85.9	...	...	13.2	84.0	12.3	82.4	9.7	76.3	...	...
May 15	13.7	82.5	14.1	83.0	12.5	80.6	...	...	13.9	84.1	14.2	85.0	12.3	84.1	...	...	14.5	84.0	14.6	86.0	12.4	79.1	...	...
May 22	13.7	85.0	12.6	82.1	14.1	84.9	10.5	78.6	14.7	85.5	12.5	82.2	13.1	83.1	11.6	82.2	14.4	84.1	12.5	82.2	11.3	80.8	11.3	78.3
May 29	15.9	92.0	12.8	85.4	13.2	84.2	11.1	79.7	13.7	85.6	13.7	85.6	11.5	82.9	11.1	81.6	13.6	86.2	13.9	89.1	12.0	85.1	11.0	82.1
June 5	14.7	88.8	13.6	87.8	14.2	88.7	12.9	87.3	15.1	89.9	14.1	89.7	14.0	83.3	13.3	88.6	14.3	88.3	14.5	84.5	13.6	88.4	13.3	87.5
June 12	13.5	88.2	12.9	85.0	13.6	90.0	12.1	87.8	14.5	88.0	14.5	86.7	13.3	87.1	13.0	88.2	13.0	91.5	13.1	87.8	14.4	92.2	12.8	89.5
June 19	14.0	85.4	12.9	83.2	12.9	81.2	13.7	86.0	12.4	82.6	15.0	85.5	13.3	81.6	12.6	83.5	13.8	84.6	13.7	86.1	12.6	82.3	13.1	81.7
June 26	11.8	81.6	12.5	82.3	12.3	82.6	11.4	80.5	11.9	80.9	11.9	80.0	12.3	83.6	11.7	81.8	11.0	80.3	11.4	78.5	13.3	83.4	13.1	84.5
July 3	11.7	81.7	12.7	84.8	12.7	85.1	11.9	81.5	12.9	84.2	12.2	87.2	12.3	82.0	12.0	85.8	12.6	84.4	12.3	84.4	13.2	83.5	12.6	83.1
July 10	11.7	81.8	11.0	82.0	12.5	84.5	11.2	80.0	11.8	82.0	10.7	77.2	11.6	81.7	12.7	82.5	11.6	83.8	12.7	83.0	12.7	81.0	12.8	84.7
July 17	...	...	...	...	11.2	80.7	9.8	74.5	...	...	...	...	10.9	79.7	10.5	79.1	...	...	...	...	10.4	80.0	9.2	78.0

The first planting, November 27, matured beets earlier and the first samples were gathered May 1. The second and third plantings were harvested first on May 8 for analyses, but the beets were really not ready until May 15. The last planting was three to four weeks later. It is probable that the early planting is the better, as the beets can get a start before cold weather begins, particularly the cold rains, and it is much easier, as a general rule, to get the seed up to a stand. The sucrose content will average somewhat lower than in 1921 for all plantings except the first, which is practically the same.

There was less variation in the size of the beets than in 1921, as shown in Table 8.

TABLE 8

Average Weight of Beet Analyzed—Grams

	Date of Planting			
Variety	Nov. 27	Dec. 27	Jan. 23	Feb. 17
Jaensch Victrix 12844	880	590	570	580
Great Western Home Grown	965	770	600	670
Kleinwanzleben	650	640	720	665
Alvarado	605	670	640	650
Kleinwanzleben elite	610	640	690	575
Dippe	690	575	605	670

The date of planting had a decided influence on the yield per acre. The early planting produced a larger tonnage with all varieties, except two. The data are presented in Table 9.

TABLE 9

Calculated Yield per Acre—Tons

	Date of Planting			
Variety	Nov. 27	Dec. 27	Jan. 23	Feb. 17
Jaensch Victrix 12844	22.8	16.6	13.2	13.8
Great Western Home Grown	16.6	16.6	16.6	11.4
Kleinwanzleben	23.9	17.0	14.1	15.4
Alvarado	23.9	16.1	13.2	15.8
Kleinwanzleben elite	22.1	19.8	14.5	13.6
Dippe	17.2	22.0	13.2	15.6

As in 1921, the cost of production was recorded. One hundred ten hours of man labor and 60 hours of horse labor were required to make the crop, calculated to the acre basis. The extra labor was necessary, for heavy rains during the early spring caused the surface soil to pack.

1922-1923

Seed of the following varieties were obtained for this season:

Variety	Source
Sperling Type A elite	Sugar Plant Investigations, Bureau Plant Industry.
Kleinwanzleben and Dippe (Mixed)	Sugar Plant Investigations, Bureau Plant Industry.
Kleinwanzleben elite	Sugar Plant Investigations, Bureau Plant Industry.
Jaensch Victrix 12844	Utah Experiment Station, Logan.
Great Western Home Grown	The Great Western Sugar Co., Denver, Colorado
Glostrup	Hjalmar Hartmann & Co., Copenhagen, Denmark.
Erhard Fredericksen's Best Danish Strain	G. D. Von Phul, New Orleans, Louisiana.

The plat used this year was not as uniform as the ones used in previous years. Cotton and corn and velvet beans were the crops for the two preceding years. It was plowed November 27, with a 26-inch reversible disc plow to a depth of about eight inches, turning under the corn stalks and bean vines. Rows three feet apart were laid off November 29. A fair seed bed was prepared and the first planting was made December 2. All varieties came up to a good stand except the Kleinwanzleben elite and Erhard-Fredericksen. The other planting dates were December 30, January 10, and January 30. All plantings on these three dates were failures, due to adverse weather conditions, and the few beets which grew were not harvested. It is almost impossible to obtain a stand if the soil is too moist or if cold rains follow immediately after planting. Beet seed contain a very small amount of plant food, so the small seedling must draw upon the soil for food very soon after germination. This season was abnormal. Three duplications were made in the first planting and the analytical results are shown in Table 10.

TABLE 10

Date of Planting—December 2, 1922

Date Harvested for Analysis	Variety											
	Jaensch Victrix 12844		Great Western Home Grown		Kleinwanzleben Dippe (Mixed)		Kleinwanzleben elite		Glostrup		Sperling Type elite A	
	Per Cent Sucrose	Purity	Per Cent Sucrose	Purity	Per Cent Sucrose	Purity	Per Cent Sucrose	Purity	Per Cent Sucrose	Purity	Per Cent Sucrose	Purity
May 21	10.2	84.8	10.0	83.7	10.5	86.5	...	...	10.3	85.4	10.9	86.1
May 28	12.3	85.0	13.1	83.5	11.6	76.2	...	...	13.3	85.2	13.9	80.4
June 4	13.6	83.9	12.5	80.0	14.5	82.3	...	...	14.1	83.9	14.5	83.8
June 11	13.8	83.5	14.7	83.9	14.7	84.8	...	...	13.8	84.4	13.6	82.6
June 18	13.4	83.9	13.0	79.4	14.5	86.9	12.6	81.1	14.3	85.6	14.6	86.7
June 25	13.4	84.5	12.3	83.2	15.0	83.1	12.6	82.8	13.7	84.5	13.3	82.5
July 2	12.4	81.9	11.8	83.0	13.9	86.4	11.8	81.6	14.0	86.5	11.0	80.0

In Table 10 the beets were not sufficiently mature to harvest until May 28. From May 28 to July 2, inclusive, the sugar content did not show much variation. The Kleinwanzleben elite was harvested for analysis only three times and then gave a low per cent of sucrose. The short season and late maturity was probably due to the excessive rainfall and cold weather. The writer's diary indicates that there were only 140 days of sunshine without rain, 126 cloudy and threatening days and 99 rainy days at the Experiment Station Farm in 1923. Many of the cloudy and threatening days were cold. The beets made a fairly good growth and five varieties did not show very much difference in sucrose.

The average size of the beets harvested for analyses is given in Table 11.

TABLE 11

Average Weight of Beet Analyzed—Grams

Variety				
Jaensch Victrix 12844	Great Western Home Grown	Kleinwanzleben and Dippe (Mixed)	Glostrup	Sperling Type A elite
370	405	475	410	460

Comparing the weight of the beets analyzed with those of the previous years, it will be noticed that they are considerably smaller. It was impossible to keep the soil in a loose condition, which may account for the small size.

The yield per acre is shown in Table 12.

TABLE 12

Calculated Yield per Acre—Tons

Variety				
Jaensch Victrix 12844	Great Western Home Grown	Kleinwanzleben and Dippe (Mixed)	Glostrup	Sperling Type A elite
7.9	10.0	8.8	7.3	8.2

The yield per acre was a decided decrease from the other two years. It is believed that the abnormal weather contributed to this condition. The yield of sugar cane and the number of pounds of sugar recovered from a ton of cane was considerably decreased from the normal in 1923. Here, again, seasonal influences played a large part, though had the planting been earlier, the tonnage would probably have been greater.

In co-operation with Mr. G. D. Von Phul, New Orleans, sugar beet seed of two varieties was distributed to a number of interested persons living in the sugar-cane section of Louisiana. Von Phul distributed the seed at his own expense. Data from this co-operative project are given in Table 13.

TABLE 13

Analytical Data of Beets Grown Away from the Experiment Station—1923

Grown by	Date Harvested for Analysis	Variety					
		Great Western Home Grown		Erhard-Fredericksen		Kleinwanzleben	
		Sucrose	Purity	Sucrose	Purity	Sucrose	Purity
R. T. Gibbens, Minerva, La., Lafourche Parish........	May 10.....	6.5	63.5	...	...	...	...
	June 7......	11.6	78.6	12.1	79.8	...	...
	July 5......	10.1	76.7	10.6	75.6	...	...
Dugas & LeBlanc, Paincourtville, La., Assumption Parish	May 10.....	8.7	74.7	...	...	...	...
	June 7......	11.3	77.2	...	...	...	...
R. G. Malhiot. Killona, La., St. Charles Parish........	May 10.....	12.1	84.7	7.5	68.2	...	...
	June 7......	12.9	81.3	12.0	78.7	...	...
	June 29.....	11.2	80.4	10.8	79.1	...	...
	July 5......	9.9	78.7	...	...	...	...
	July 15.....	9.0	73.7	...	...	...	...
Pitcher Bros., Lakeland, La., Pointe Coupee Parish....	May 10.....	9.9	74.9	...	...	...	...
	June 22.....	10.8	77.8	...	...	...	...
	July 2......	11.4	80.1	...	...	...	...
P. G. Songy, Wallace, La., St. James Parish............	May 10.....	10.4	76.5	...	...	...	...
	June 5......	14.4	84.2	...	...	...	...
	June 28.....	12.0	83.2	...	...	...	...
	July 10.....	12.1	83.7	...	...	...	...
Laurel Grove Co., Thibodaux, La., Lafourche Parish...	June 19.....	12.8	79.2	...	...	...	...
	June 30.....	8.6	77.1	...	...	...	...
Devall Planting Co., Chamberlin, La., West Baton Rouge	June 2......	8.1	76.1	...	...	...	...
E. E. Wunsch, Denham Springs, La., Livingston Parish..	May 30.....	...	...	...	...	17.2	90.1

The variety grown by Mr. Wunsch was Kleinwanzleben, and the seed was purchased by him. Denham Springs is 15 miles east of Baton Rouge. The soil in that vicinity is considerably coarser in texture than the bluff soils adjacent to the Mississippi River. The high sucrose content may be due to a difference in soil type.

The beets grown in the alluvial lands of the Mississippi River showed a marked decrease in sucrose content but gave a large yield. This being the first year that beets, for analytical purposes, have been grown in these soils, it is impossible to state any conclusions.

The calculated yield per acre of the beets grown in the co-operative experiment are given in Table 14.

TABLE 14

Calculated Yield per Acre—Tons

Grown by	Variety	
	Great Western Home Grown	Erhard-Fredericksen
R. T. Gibbens	14.5	15.8
Dugas & LeBlanc	15.8	...
R. G. Malhiot	26.7	17.6
P. G. Songy	22.9	...

1923-1924

It proved rather difficult to get seed for this season. However, the following varieties were finally obtained:

Variety	Source
Erhard-Fredericksen's Best Danish Strain	C. M. Baumgarten, Bay City, Michigan.
Great Western Home Grown	The Great Western Sugar Co., Denver, Colorado.
Jaensch Victrix 12844	Utah Experiment Station, Logan.
Kleinwanzleben	New Mexico Experiment Station, College Station.
Kleinwanzleben Original "Rabbethge-Giesecke"	National Seed Co., New York.
Glostrup	Hjalmar Hartmann & Co., Copenhagen, Denmark.
Dippe	W. B. Rosevear, Jr., Detroit, Michigan.

All varieties were imported except the Great Western Home Grown, the Jaensch Victrix 12844, and the Kleinwanzleben from New Mexico. It was planned to make four different plantings with three or four weeks intervening. All seed was not obtained until the first of December, and then weather conditions were far from favorable. Only one planting was finally made, January 31, 1924. On that date seven duplications were planted in rows two feet nine inches wide on a plat where corn and cowpeas and red clover had been grown for a number of years. The soil was broken as heretofore and the seed bed was in very good condition at time of planting. Practically a perfect stand was gotten on all rows. A hard freeze in December and another the middle of January would probably have killed all the plants had earlier planting been possible. The analytical data is shown in Table 15:

TABLE 15

Variety

Date Harvested for Analysis	Erhard-Fredericksen		Great Western Home Grown		Jaensch Victrix 12844		Kleinwanzleben (New Mexico)		Kleinwanzleben (Germany)		Glostrup		Dippe	
	Per Cent Sucrose	Purity	Per Cent Sucrose	Purity	Per Cent Sucrose	Purity	Per Cent Sucrose	Purity	Per Cent Sucrose	Purity	Per Cent Sucrose	Purity	Per Cent Sucrose	Purity
June 6......	10.0	75.0	9.7	76.0	9.8	77.6	9.9	76.3	9.9	76.3	10.4	75.0	9.3	73.8
June 12.....	11.3	76.7	12.3	81.3	11.9	78.6	12.1	75.3	11.6	79.5	11.0	74.8	11.8	77.1
June 18.....	12.7	80.0	13.8	81.9	12.8	80.6	13.6	82.0	12.8	80.3	13.5	82.6	11.8	78.7
June 26.....	13.7	80.2	15.0	82.0	14.6	81.2	13.7	82.9	15.5	84.6	15.2	84.5	15.6	86.9
July 3......	14.2	81.8	15.5	81.3	14.8	83.1	14.4	81.3	14.5	84.5	15.2	83.8	14.8	82.7
July 10.....	14.5	81.4	13.7	80.0	11.3	75.5	13.7	78.8	13.8	79.3	14.4	81.5	14.3	79.6
July 17.....	14.0	78.4	15.2	80.9	14.9	82.7	15.6	81.5	15.6	81.2	16.3	84.0	14.6	79.4
July 24.....	13.4	81.0	13.5	83.5	13.6	81.7	13.7	81.6	15.3	82.6	12.5	79.2	13.0	81.2
July 31.....	13.4	79.0	13.7	79.0	14.9	79.3	13.6	80.3	14.3	80.2	13.6	81.9	14.0	82.0

The samples harvested June 6 and 12 were preliminary in order to find out how the sugar content was developing. The growing season had been cold and wet up to the middle of May and the beets made a slow growth. These two analyses should not be considered as a part of the season and the seven analyses following show about the same results as in previous years. The Great Western Home Grown was the highest and most consistent in sucrose content.

The average size of the beets was about the same as in 1923. This data for 1924 are presented in Table 16.

TABLE 16

Average Weight of Beet Analyzed—Grams

Variety

Erhard-Fredericksen	Great Western Home Grown	Jaensch Victrix 12844	Kleinwanzleben (New Mexico)	Kleinwanzleben (Germany)	Glostrup	Dippe
500	575	550	495	530	470	485

The yield per acre is low again, due, no doubt, to excessive rain and cold weather in early spring. As during the previous season, it was extremely difficult to keep the soil in good tilth. Table 17 shows the tons per acre.

TABLE 17

Calculated Yield per Acre—Tons

Variety

Erhard-Fredericksen	Great Western Home Grown	Jaensch Victrix 12844	Kleinwanzleben (New (Mexico)	Kleinwanzleben Germany)	Glostrup	Dippe
7.75	8.00	7.70	8.00	8.65	7.70	9.25

The labor cost per acre to grow the beets amounted to 173 man hours and 80 horse hours. Here again, the effect of the seasonal influence is self-evident.

Seed of two varieties was again distributed, the Great Western Home Grown by Mr. G. D. Von Phul of New Orleans, and the Kleinwanzleben (Germany) by the Experiment Station. The extreme cold in December and January killed all of the early plantings. The analytical data of all beets sent to the Experiment Station is given in Table 18.

TABLE 18

Grown by	Date Planted	Date Harvested	Date Analyzed	Variety			
				Great Western Home Grown		Kleinwanzleben	
				% Sucrose	Purity	% Sucrose	Purity
Sterling Sugars Co., Franklin, La., St. Mary Parish	Jan. 12	May 16	May 19	12.64	74.35	....	....
	Jan. 12	June 9	June 12	10.10	72.80	....	....
	Jan. 12	June 15	June 18	12.50	70.70	....	....
Pitcher Bros., Lakeland, La., Pointe Coupee Parish	....	May 21	May 23	10.89	76.50	....	....
	....	June 16	June 18	9.20	69.60	....	....
	....	June 22	June 24	8.70	64.70	....	....
	....	July 1	July 3	9.80	74.20	....	....
	....	July 8	July 10	10.00	68.10	....	....
State Farm, Angola, La., West Feliciana Parish	Mar. 5	June 10	June 12	....	....	9.60	70.20
	Mar. 5	June 20	June 24	....	....	12.40	72.50
	Mar. 5	June 28	June 30	....	....	15.30	84.60
T. I. Watson, Tallulah, La., Madison Parish	Jan. 29	June 9	June 12	....	....	11.00	80.50
	Jan. 29	June 15	June 18	....	....	8.50	65.30
	Jan. 29	June 25	June 28	....	....	9.50	70.40
	Jan. 29	Aug. 4	Aug. 6	....	....	9.30	68.90
H. P. Overton, Pride, La., East Baton Rouge Parish	Dec. 31	June 14	June 16	....	....	14.10	83.00
Fruit and Truck Station, Hammond, La., Tangipahoa	....	June 19	June 20	....	....	15.00	82.60
E. E. Wunsch, Denham Springs, La., Livingston Parish	Mar. 1	June 19	June 20	....	....	13.70	80.20
	Mar. 1	July 2	July 3	....	....	13.50	76.30
	Mar. 28	July 2	July 3	....	....	14.60	80.20
Guy Fletcher, Centerville, La., St. Mary Parish	Mar. 2	July 7	July 9	....	....	19.90	85.00

The results for this year are practically the same as for last season, that is, the beets grown on the heavy alluvial clay soils had a low sucrose content while those grown on the lighter upland soils and the sandy loams of the alluvial sections were about the same as last year. It was impossible to get the yield data on the beets grown co-operatively. There were poor stands in most instances.

The data from the four years' results seem to indicate that sugar beets could probably be grown commercially. However, the writers are not ready to recommend the crop for this purpose. Further experiments will be conducted.

In order to get some idea of the keeping qualities of the beets and to throw some light on the transportation problem, beets were harvested at the Experiment Station and treated to two different conditions. The results are given in Table 19.

TABLE 19

Date Harvested	Date Analyzed	Per Cent Sucrose	Purity	Remarks
June 25.......	June 25.......	13.00	79.30	Sent to laboratory as soon as harvested.
June 25.......	June 26.......	14.90	80.20	Exposed to sun one day in field.
June 25.......	June 30.......	16.20	75.50	Exposed to sun one day in field. Placed in wagon box and exposed to sun four days. Sample taken from top of pile.
June 25.......	June 30.......	13.50	78.90	Same as above. Sample taken from middle of pile.
June 25.......	June 30.......	14.90	80.10	Same as above. Sample taken from bottom of pile.
June 25.......	July 10.......	14.80	72.20	Exposed to sun one day in field. Exposed to sun four days in wagon. Exposed on ground in driveway of barn nine days.
July 9........	July 9........	13.50	76.30	Sent to laboratory as soon as harvested.
July 9........	July 10.......	13.80	74.60	Exposed to sun one day in field.
July 9........	July 18.......	14.20	74.80	Exposed to sun one day in field and in wagon under shed seven days.
July 9........	July 24.......	13.40	69.40	Exposed to sun one day in field and in wagon under shed fourteen days.
July 9........	July 31.......	14.20	65.80	Exposed to sun one day in field and in wagon under shed twenty-one days.

The data in Table 19 indicate that sugar beets may be piled in the field one day after harvesting and then kept in the shade for a week without any great deterioration. If the beets could be placed in a stock car for transportation, which would permit ventilation and at the same time keep them in the shade, it is probable that the movement from field to factory would be a success. Note the difference in the analysis of the sample from the top of the pile in the wagon box after being in the sun for five days, and the analysis of the middle sample, as well as the bottom sample. Beets harvested and exposed to the sun for one day and then stored in the shade for seven days showed practically no deterioration.

Summary

1. Sugar beets contain 13% to 14% sucrose with a purity of 80 to 85, have been successfully grown on the bluff soils adjacent to Baton Rouge and on the cut-over pine lands to the east. Possibly the alluvial soils may also be used for this crop. It is considered that such beets are sufficiently rich in sucrose for commercial purposes.

2. Ten to 15 tons per acre can be produced. The average yield per acre in the United States is approximately 9.5 for a nine-year average.

3. Cost of production is comparatively low.

4. The length of season for harvesting has varied in the past four years from 7 to 12 weeks, beginning about May 1.

5. It is believed that the planting in these tests has not been sufficiently early. September and October plantings will no doubt prove advantageous.

6. Sugar beets generally weigh from one to two pounds when harvested. Uniformity in size, while not necessary, is a good feature.

7. No fertilizers were used in any of the tests at Baton Rouge.

E. C. Auchter

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FUNGOUS INFECTION OF SEED CORN KERNELS AND THE IMPORTANCE OF GERMINATION TESTS

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FUNGOUS INFECTION OF SEED CORN KERNELS AND THE IMPORTANCE OF GERMINATION TESTS

C. W. EDGERTON and A. F. KIDDER

While corn is one of the major agricultural crops of Louisiana, the low yields make it of less importance than it should be. The yields in the state for the past ten years have varied between sixteen and twenty-two bushels per acre and these are too low for much profit.

Without doubt there are many factors responsible to a more or less extent for the low yields. Among these should be mentioned soil fertility, cultivation methods, drainage conditions and the attack of insects and diseases There is no way at present of telling the relative importance of any of these factors. In varying degrees, these factors are influenced by one another.

One of the factors which has received considerable attention in recent years by workers in other states and in the Federal Department of Agriculture is the infection of seed corn grains with certain fungous parasites. A number of bulletins and articles have been published showing the relation of this infection to vitality, germination, grain production and the amount of root rot on the growing plants. Briefly, the results from various places seem to show that a considerable portion of the corn in the United States is infected with fungi, and it is generally assumed that this infection affects the germination of the seed and the yield of the crop. Consequently, it has been generally recommended that corn which does not show a high germination or does not produce plants of rapid and strong growth in the germinator should not be used for seed.

As preliminary tests had shown that Louisiana corns were badly infected with some of these fungi, experiments were planned to determine how important this factor is to the corn crop of the state. The experiments have run over a period of four years. The things which we have tried to bring out in these tests include the following:

(1) The percentage of Louisiana corn, and especially seed corn, that is infected with each of the common fungi.

(2) The effect of this infection upon germination and yield.

(3) The relation between the apparent vitality of the corn as shown by germination tests and yield.

FUNGI IN CORN GRAINS

Tests made in various parts of the United States have shown that four fungi are commonly found inside the grains of corn. The fungi are in the mycelial stage and are generally within the seed coats at the tip of the kernel, evidently growing into the kernels while the ears are maturing. The fungi mentioned as occurring in most abundance are *Gibberella saubinetii, Diplodia zeae, Fusarium moniliforme* and *Cephalosporium acremonium.*

Gibberella saubinetii is a common parasite of small grains and corn, causing the common scab of wheat and one of the root rot diseases of corn. It is widely distributed in the corn belt area of the United States, but has apparently not been reported in Louisiana.

Diplodia zeae is the cause of the common dry rot disease of corn ears. The ears rot and the shucks are generally cemented together and to the rotting kernels by a white mold or mycelium. This fungus is common in most parts of the United States, including Louisiana.

Fusarium moniliforme is the fungus which produces the common pink rot of corn kernels. It is widely distributed over the United States, including Louisiana.

Cephalosporium acremonium is a fungus which seems to be widely distributed over the United States, including Louisiana. This is the same fungus which Manns in recent publications called *Cephalosporium sacchari. C. sacchari* is a sugar cane fungus and apparently has no connection with the corn parasite.

The work which has been done on these fungi at various places has been thoroughly reviewed in a recent bulletin from the Illinois Experiment Station* and consequently will not be discussed in this publication. At this time it only seems necessary to give the actual results which have been obtained from the Louisiana experiments.

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*Holbert, J. R.; Burlison, W. L.; Koehler, B.; Woodworth, C. M., and Dungan, G. H. Corn root, stalks and ear rot diseases and their control through seed selection and breeding. Illinois Experiment Station Bulletin 255 (1924).

In determining the presence of fungi in Louisiana corns, practically the same procedure has been followed as has been used at other stations. The grains were first soaked for three to five minutes in a corrosive sublimate alcohol solution. The corrosive sublimate was at the strength of one to one thousand, this being dissolved in a 50 per cent alcohol solution. Then, after thoroughly rinsing in sterile water, the kernels were placed in nutrient media in petri dishes and allowed to incubate. If any fungi were present, the mycelium would grow out on the culture media and could be identified after a period of six to nine days (Fig. 1). During the later years of the work, a drop of 50 per cent lactic acid was dropped into each agar tube before

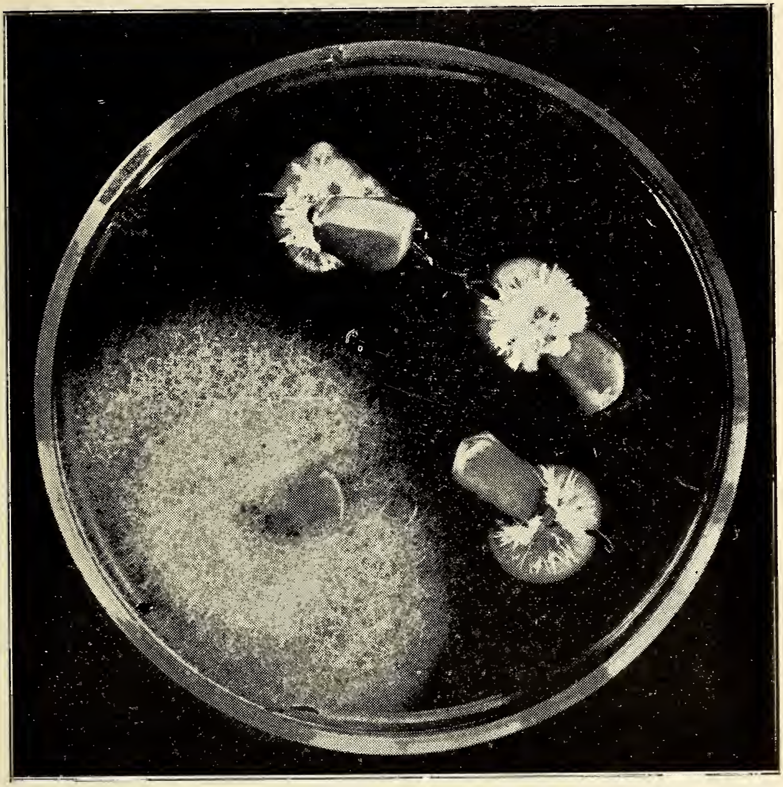

Fig. 1. Sterilized corn grains in culture media in petri dish. Three of the kernels show a growth of *Cephalosporium acremonium* and one of *Fusarium moniliforme.*

pouring into the petri dish. This eliminated a large part of the bacterial contamination and did not hinder the growth of any of the important fungi. Corns from three successive crops have been tested.

In order to obtain the general distribution of the kernel infection, samples were obtained from a large number of the corn exhibits at the State Fair at Shreveport in the fall of 1921. This corn had all been closely selected and was, of course, above the general run of corn in soundness and freedom of rot. The samples were from various parts of the state and represented the best of the Louisiana corn for that season. These were brought to Baton Rouge and were cultured in the manner described above, sixteen to twenty kernels of each sample being used. In Table 1 are given the results of this test. In this table only the infection with the two common fungi is given. Various other fungi, such as Aspergillus and Penicillium, were also present to a certain extent, but neither these nor the bacterial contaminations seem to be important. As acid was not used in the plates, it was not always possible to eliminate all bacterial growth.

Table 1

FUNGI IN CORN FROM STATE FAIR SAMPLES, 1921

Variety	Parish	Number of Kernels With Different Fungi		
		Total	With *Fusarium moniliforme*	With *Cephalosporium acremonium*
Calhoun Red Cob	Bossier	20	8	4
Calhoun Red Cob	Bossier	16	10	0
Calhoun Red Cob	De Soto	20	10	4
Calhoun Red Cob	Webster	20	8	10
Calhoun Red Cob	Webster	16	12	2
Calhoun Red Cob	Webster	16	5	8
Calhoun Red Cob	Lincoln	20	7	2
Calhoun Red Cob	Lincoln	20	11	2
Calhoun Red Cob	Union	20	9	5
Calhoun Red Cob	Union	16	6	7
Calhoun Red Cob	Union	16	0	10
Calhoun Red Cob	Union	16	2	7
Calhoun Red Cob	Union	16	5	7
Calhoun Red Cob	Union	16	5	9
Calhoun Red Cob	Union	16	8	3
Calhoun Red Cob	Grant	20	13	5
Calhoun Red Cob	Grant	20	13	7
Calhoun Red Cob	Grant	20	8	8
Calhoun Red Cob	Ouachita	20	6	8
Calhoun Red Cob	Ouachita	16	6	6
Calhoun Red Cob	Morehouse	16	10	4
Calhoun Red Cob	East Carroll	20	11	7
Calhoun Red Cob	East Carroll	20	8	10
Calhoun Red Cob	East Carroll	20	3	12
Calhoun Red Cob	East Carroll	16	4	11
Calhoun Red Cob	East Carroll	16	7	1
Calhoun Red Cob	Madison	20	19	0
Calhoun Red Cob	Madison	20	2	14
Calhoun Red Cob	Madison	16	8	3
Calhoun Red Cob	Madison	16	7	7
Calhoun Red Cob	Madison	16	11	1
Calhoun Red Cob	Washington	16	6	2
Calhoun Red Cob	Calcasieu	20	10	5
Calhoun Red Cob	(?)	20	13	4
Calhoun Red Cob	(?)	16	1	13
Calhoun Red Cob	(?)	16	4	2
White Calhoun	Morehouse	20	11	2
White Calhoun	Ascension	20	19	1
Yellow Calhoun	East Carroll	20	9	8
Yellow Calhoun	East Carroll	20	8	12
Stewart's Yellow Dent	Caddo	20	16	1
Rogers	Bossier	20	7	6
Rockdale	Caddo	20	2	15
Hastings	Ascension	20	4	7
Yellow Creole	Grant	16	5	6
Yellow Creole	Lafayette	16	2	7
Mexican June	East Carroll	16	9	6
Sentell's White Dent	(?)	20	6	7
Sentell's White Dent	(?)	16	10	3
(?)	Bossier	20	9	5
(?)	East Baton Rouge	20	13	6
(?)	(?)	16	12	3
	Total	944	418	305
	Per Cent	...	44.3	32.3

As is indicated by the table, all of the State Fair samples were infected with either *Fusarium moniliforme* or *Cephalosporium acremonium*, and most of them with both. Over 76 per cent of the kernels showed an internal infection with these fungi. Of the two, *Fusarium moniliforme* was slightly more abundant. Neither *Gibberella saubinetii* nor *Diplodia zeae* was found in these kernels.

The table also shows that the two fungi were well scattered over the state, with no section showing any apparent freedom from infection. Though possibly in a less amount, the infection is also seen in the extremely hard flint variety, Yellow Creole, as well as in the dent variety, Calhoun Red Cob.

In the tests described above, the kernels used were from composite samples and not from individual ears. Information, however, has been obtained upon individual ears from corn grown at Baton Rouge. Kernels from a great many ears from the crops of 1921, 1922 and 1923 were cultured. Sixteen kernels were cultured from each ear of the 1921 and 1922 crops tested and four from the 1923 crop. These ears were later used in ear-to-row planting tests in order to ascertain the effect of the infection. The variety used was White Calhoun. The fungus infection found in these ears is given in Table 2.

Table 2

FUNGOUS INFECTION IN INDIVIDUAL EARS

	Year Crop Was Grown		
	1921	1922	1923
Number of ears cultured	198	304	180
Number of ears with *Fusarium moniliforme* alone	40	114	66
Number of ears with *Cephalosporium acremonium* alone..........................	17	24	31
Number of ears with Fusarium and Cephalosporium	141	164	74
Number ears with neither Fusarium nor Cephalosporium		2	9
Number of kernels cultured........................	3168	4864	720
Number of kernels with *Fusarium moniliforme*...	1577	2581	406
Percentage of kernels with *Fusarium moniliforme*	49.8%	53.1%	56.4%
Number of kernels with *Cephalosporium acremonium*	954	1181	222
Percentage of kernels with *Cephalosporium acremonium*	30.1%	24.3%	30.8%
Number of kernels with neither Fusarium nor Cephalosporium	637	1102	92

An examination of Tables 1 and 2 shows that the Louisiana corns have an internal infection with *Fusarium moniliforme* of approximately 50 per cent and with *Cephalosporium acremonium* of about 30 per cent. The tables also show no infection with *Gibberella saubinetii* nor with *Diplodia zeae*. *Gibberella saubinettii* has not as yet been recognized on corn in Louisiana. Whether its apparent absence is due to the small amount of wheat grown in the state has not been determined. Under present conditions, then, this fungus has no bearing on the corn situation in Louisiana. The absence of *Diplodia zeae* in the cultures is doubtless due to the fact that only carefully selected seed corn was used for culturing. Ears affected with the Diplodia are mostly discarded when the seed corn is being selected. The fungus is very common in Louisiana and doubtless causes more damage in the field than in states farther to the north. From the seed corn standpoint in Louisiana, the fungous infection factor narrows down to the two fungi, *Fusarium moniliforme* and *Cephalosporium acremonium*.

FIELD TESTS

To determine the effect of kernel infection and other factors on yield, a series of ear-to-row tests was carried on during the

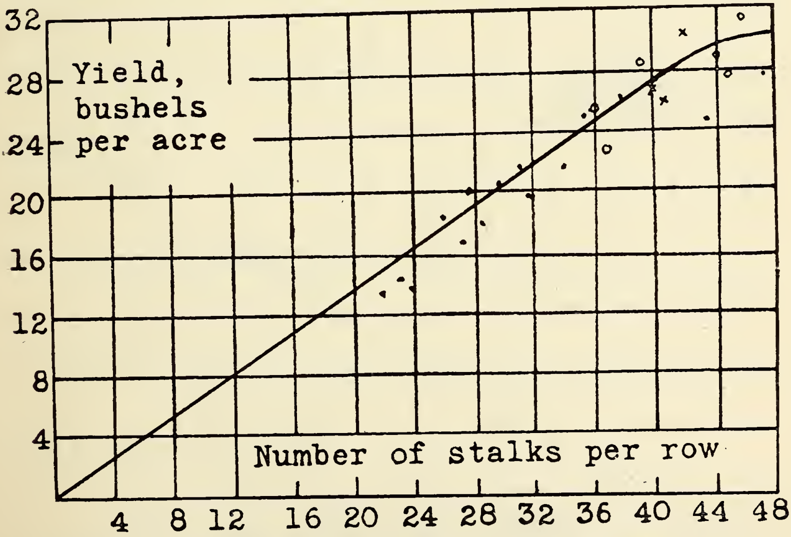

FIG. 2. Curve showing the relation between stand and yield in 1921. For a perfect stand there should have been 48 plants to 96 feet. For each cross (X), eight or more rows were averaged; for each circle (O), four to seven; and for each dot (.), one to three.

seasons of 1921, 1922, 1923 and 1924 at Baton Rouge. Ears that were apparently sound were selected for the work. Kernels from each ear were cultured, notes taken on dentation, soundness, etc., and germination tests made. The results of the cultures have already been given in Table 2. In the spring, the ears were planted in 96-foot rows with the hills 2 feet apart. After the plants were six to eight inches high, the hills were thinned to one plant. Each row was harvested separately and counts made of the actual number of plants. At the end of the season there was a complete record for each ear and it was possible to make any comparisons which seemed important.

RELATION OF STAND AND YIELD

On account of soil and weather conditions and the attack of root worms and borers, it is not always possible to have equal stands in different corn rows in Louisiana. The general field practice is to plant an abundance of seed and then thin out the young plants to the desired stand. Even under the most favorable conditions, there will be gaps at thinning time or plants will be killed after the thinning has been done. This factor of unequal stands must be taken into consideration in field tests.

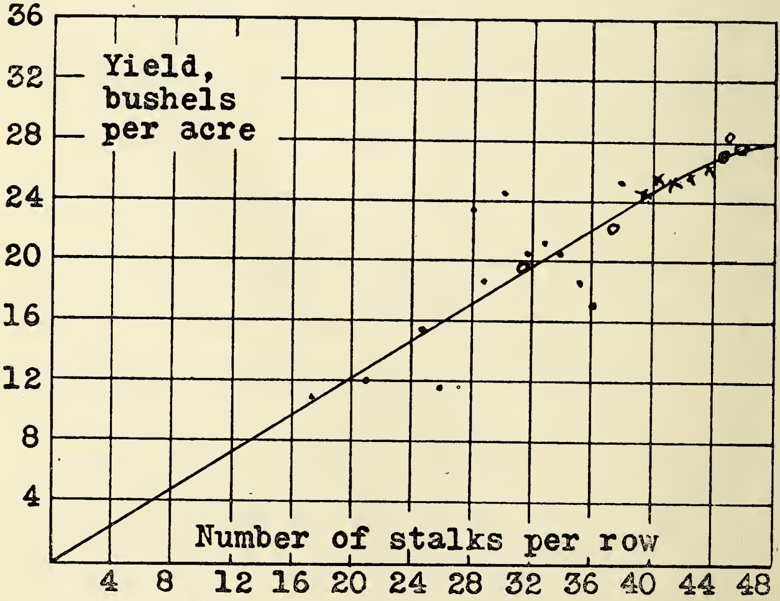

FIG 3. Curve showing the relation between stand and yield in 1922.

In the ear-to-row tests carried on during the years 1921 to 1924, for a perfect stand there should have been 48 plants to each 96-root row. As a matter of fact, under the actual conditions, there was considerable variation. In order to compare the rows containing varying numbers of plants, it first became necessary to determine the actual relation between stand and yield. An attempt has been made to show this relation in Table 3 and in Figs. 2 to 5.

Table 3 gives the average yield of all the rows in each experiment having approximately the same number of plants.

Table 3

RELATION OF STAND AND YIELD

Stalks per Row	1921		1922		1923		1924	
	Number of Rows	Yield, Bu. per Acre	Number of Rows	Yield, Bu. per Acre	Number of Rows	Yield, Bu. per Acre	Number of Rows	Yield, Bu. per Acre
45-48	18	29.0	10	28.0	7	29.6	67	24.7
41-44	26	28.0	39	25.9	34	26.1	31	22.7
37-40	26	25.8	28	24.8	37	26.1	36	18.5
33-36	9	25.0	9	19.3	30	21.8	18	18.1
29-32	12	20.3	7	20.1	18	20.6	6	16.2
25-28	5	19.0	4	18.3	15	18.3	5	12.0
21-24	3	13.9	1	12.0	8	16.7	9	11.3
11-20	..	...	..	...	..	...	8	7.2

In Figs. 2 to 5, the relation between stand and yield is shown by means of curves. The average yields of the rows containing the same number of plants were plotted and the curves drawn. In the figures, a cross (X) means that there were eight or more rows averaged, a circle (O) between four and seven rows, and a dot (.) only one to three rows. In drawing the curves, the location of the crosses were of considerably more importance than that of the dots.

An examination of the figures shows that there is a direct relation between stand and yield and that up to a certain point

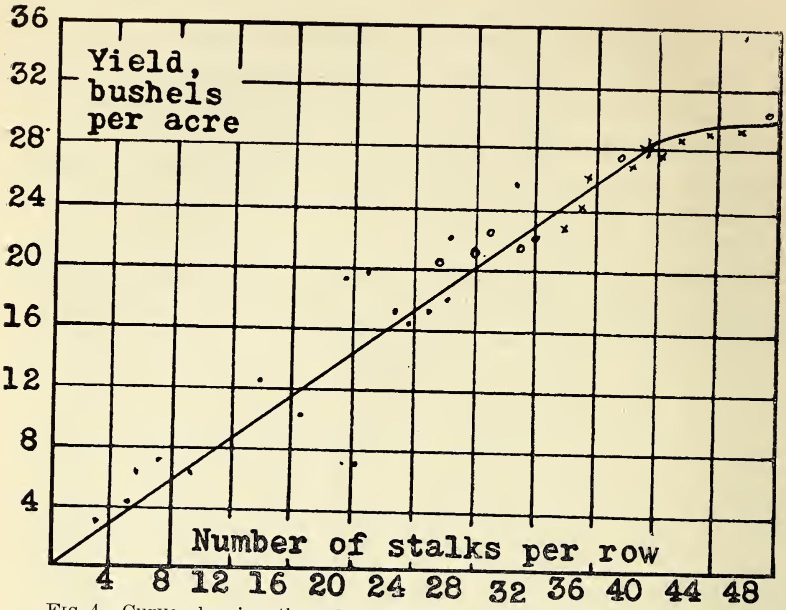

FIG. 4. Curve showing the relation between stand and yield in 1923.

the curves showing this relation are practically straight lines. Not until the stands rise above 40 to 45 stalks to the row do the curves show a tendency to bend.

METHOD OF ESTIMATING FACTOR EFFECTS

The curves in Figs. 2 to 5 have been used as a basis in estimating the effects of various factors, such as kernel infection. The curves show the expected yields of the rows with the different stalk numbers. The expected yield is represented by the curves in the graph. By comparing the yields actually obtained in the field with the expected yield, as shown by the curves, the actual deviation is readily obtained. By averaging the deviation of all the rows influenced by a certain factor, a fair idea of the effect of that factor can be obtained. In the following pages the factors of kernel infection, germination, etc., have been estimated in this manner.

EFFECT OF KERNAL INFECTION

The effect of kernel infection has been figured on the three crops of 1922, 1923 and 1924.

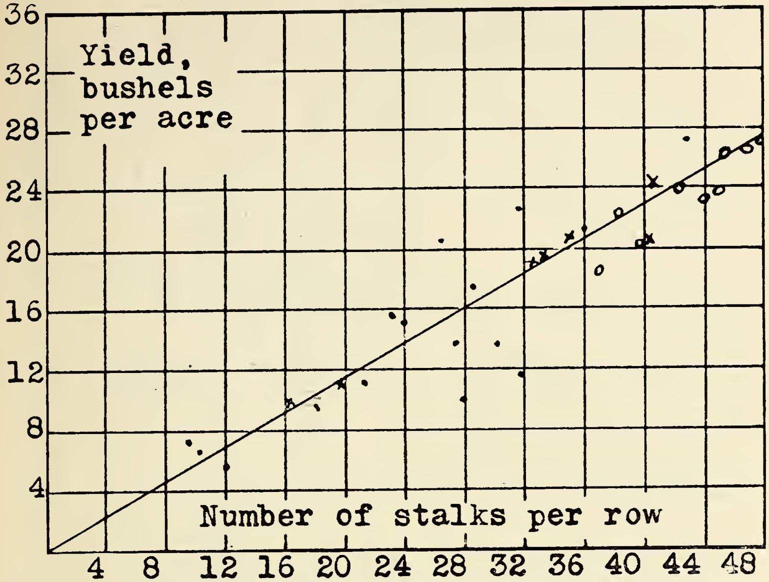

FIG. 5. Curve showing the relation between stand and yield in 1924.

In 1922, there were 97 ears in the test. Sixteen kernels from each ear were cultured. These were grouped into four classes as follows:

(a) Ears with more than half of the kernels showing an infection with *Fusarium moniliforme* but none with *Cephalosporium acremonium.*

(b) Ears with more than half of the kernels with *Fusarium moniliforme* but a few of the others with *Cephalosporium acremonium.*

(c) Ears with more than half of the kernels showing an infection with *Cephalosporium acremonium* but none with *Fusarium moniliforme.*

(d) Ears with more than half of the kernels with *Cephalosporium acremonium* but a few of the others with *Fusarium moniliforme.*

The data obtained on the 1922 test are given in Table 4. The table gives the number of ears in each class, the actual stand, the actual yield, the laboratory germination test and the deviation from the expected yield as shown by the curve.

Table 4

EFFECT OF KERNEL INFECTION IN 1922

Classes	(a) *Fusarium moniliforme*	(b) Mostly *Fusarium moniliforme*	(c) *Cephalosporium acremonium*	(d) Mostly *Cephalosporium acremonium*
Number of ears	20	45	7	25
Field germination, per cent	44.3	44.7	49.4	45.6
Average stand, per cent	80.7	80.7	82.7	82.9
Average yield, bu. per acre	23.7	24.2	24.3	24.7
Number of ears producing more than expected shown in the curve	10	17	3	13
Number producing less than expected	9	20	4	12
Number producing same as expected	1	8	0	0
Average deviation, bu. per acre	+0.1	+0.2	—0.2	+0.3

As shown by the table, no appreciable difference can be seen between the ears infected with *Fusarium moniliforme* and those with *Cephalosporium acremonium*.

The test in 1923 was conducted in the same manner as in 1922. The results are given in Table 5.

Table 5

EFFECT OF KERNEL INFECTION IN 1923

Classes	(a) *Fusarium moniliforme*	(b) Mostly *Fusarium moniliforme*	(c) *Cephalosporium acremonium*	(d) Mostly *Cephalosporium acremonium*
Number of ears	71	35	10	28
Laboratory germination, per cent	95	96	93	98
Stand in field, per cent	65.6	72.3	78.8	68.9
Average yield, bu. per acre	20.9	23.1	26.3	23.0
Number of ears producing more than expected shown in curve	33	17	5	14
Number producing less than expected	30	17	4	11
Number producing same as expected	8	1	1	3
Average deviation, bu. per acre	+0.05	+0.4	+1.4	+0.9

As shown by Table 5, in 1923 there was a slight variation in the actual yield, but this was entirely due to the difference in stand. The deviation from the expected yield was slight.

In 1924, 180 ears were planted, but only four kernels were cultured from each ear. As to fungous infection, the ears were classed as follows:

(e) *Fusarium moniliforme.* Only *Fusarium moniliforme* was present in the kernels cultured.

(f) *Cephalosporium acremonium.* Only *Cephalosporium acremonium* was present in the kernels cultured.

(g) Mixed. Both *Fusarium moniliforme* and *Cephalosporium acremonium* were present in the kernels cultured.

(h) Sterile or nearly so. Neither *Fusarium moniliforme* nor *Cephalosporium acremonium* were present in the kernels cultured. The cultures were sterile, or at most, contaminated with other fungi.

The results of the 1924 test are given in Table 6.

Table 6

EFFECT OF KERNEL INFECTION IN 1924

Classes	(e) *Fusarium moniliforme*	(f) *Cephalosporium acremonium*	(g) Mixed	(h) Sterile or Nearly So
Number of ears	65	24	78	13
Laboratory germination, per cent	78	83	82	90
Stand in field, per cent	80.0	89.2	80.0	91.8
Average yield, bu. per acre	19.8	21.2	19.8	23.5
Per cent of suckers to total number stalks	18.5	22.4	21.2	25.3
Number of ears producing more than expected shown in curve	25	14	28	6
Number producing less than expected	35	9	34	7
Number producing same as expected	5	1	16	0
Average deviation, bu. per acre	—0.2	+0.06	—0.25	—0.026

In 1924, as is shown by Table 6, there was also a slight variation in the actual yield, but, as in the previous year, this was entirely due to the difference in stand. The deviation from the expected yield was very slight.

From the three years' tests, there is no evidence to show that *Fusarium moniliforme* or *Cephalosporium acremonium* have any serious effect on the corn yields in Louisiana. This is in accordance with recent results obtained at other stations. It should be kept in mind, however, that all the kernels planted in Louisiana do not produce plants and it is not impossible that a greater percentage of the weaker plants or those developing from infected seed are the ones killed by adverse conditions or are cut out at thinning time. Yet as corn is grown in Louisiana, it would seem that equal yields can be expected from the plants whether the seed are infected with either of the two fungi and that neither is an important factor in corn production. It should be noted that a slightly less stand was obtained in some of the years with the corn infected with *Fusarium moniliforme,* but it does not seem that the difference is marked enough or constant enough to be important.

RELATION OF SUCKERS TO YIELD

In a recent publication, Reddy and Holbert* state that the disease known as the black bundle disease is caused by the fungus, *Cephalosporium acremonium,* and that stalks affected with this disease show a greater tendency to sucker.

To obtain information on this point, in 1924 the suckers were counted in each of the rows in the ear-to-row test. The percentage of suckers developing on the stalks from ears with the different fungous infections has already been included in Table 6. The stalks from the ears that showed neither Fusarium nor Cephalosporium had slightly more suckers, while the stalks from ears infected with Fusarium had slightly less than the others. The differences, however, are not very marked.

The relation between the yield and the number of suckers in the 1924 tests is shown in Table 7.

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*Reddy, C. S., and Holbert, J. R. The black bundle disease of corn. Journal of Agricultural Research, 27:177-206 (1924).

Table 7

RELATION BETWEEN NUMBER OF SUCKERS AND YIELD, 1924

	Number of Suckers per Row			
	None	1 to 4	5 to 10	11 and Above
Number of rows	8	59	70	43
Per cent of suckers to total number stalks	..	8.2	19.3	40.7
Stand in field, per cent	70.0	73.0	83.0	87.5
Average yield, bu. per acre	15.3	17.9	20.7	24.1
Number of rows producing more than expected shown in curve	2	21	26	24
Number of rows producing less than expected	5	28	35	17
Number of rows producing same as expected	1	10	9	2
Average deviation, bu. per acre	—0.07	—0.25	—0.28	+0.37

The year 1924 was the dryest year on record in Louisiana and consequently the corn was growing under adverse conditions. Under these conditions, the presence of suckers had but little apparent effect on the yield of individual plants, as is shown by the small deviation. Where there was the best stand, the plants showed a greater vitality, produced more suckers, and gave a larger yield.

RELATION OF GERMINATION TESTS TO YIELD

It has been generally assumed that a germination test is a reliable index of the vitality and productiveness of corn and consequently it is usually recommended that germination tests be made with all seed corn and all ears discarded that do not come up to a standard. If only a small percentage of the kernels of an ear germinate, or if the growth of the young plants immediately following germination is weak, that ear should not be used for seed.

In the corn belt area of the Middle West, where corn is not thinned out after planting and all of the kernels planted are expected to grow, a germination test is undoubtedly important. In Louisiana, however, different conditions exist. The practice of planting an excess of seed and then thinning out the plants undoubtedly decreases the importance of the germination test. Many of the weak plants die or are cut out at the time the corn is thinned. In the ear-to-row tests carried on from 1922 to 1924, an attempt was made to determine the importance of the germination test.

In 1922, two tests were made, a laboratory test and a greenhouse test.

In the laboratory test, ten kernels from each year were germinated on moist blotting paper and at the end of nine days, the ears were placed in three classes: *good, fair* and *bad.* The kernels from the ears classed as *good* practically all germinated and grew vigorously. The kernels from the ears classed as *bad* either showed a small germination percentage or else many of the young plants lacked vigor. The results obtained with these ears in the field are given in Table 8.

Table 8

RELATION OF LABORATORY GERMINATION TEST TO YIELD, 1922

Classes	Good	Fair	Bad
Number of ears	49	33	16
Field germination, per cent	50.8	48.0	33.3
Stand in field, per cent	84.0	81.5	77.7
Average yield, bu. per acre	25.4	23.1	23.4
Number of rows producing more than expected shown in curve	25	12	7
Number of rows producing less than expected	23	18	6
Number of rows producing same as expected	1	3	3
Average deviation, bu. per acre	+0.5	—1.0	+0.7

An examination of the figures in Table 8 shows that there was a slightly better stand with the ears showing good germination, but the deviation from the expected yield was not marked. In fact, the plants from the poor ears really produced more than from the good ears.

In the greenhouse test in 1922, ten kernels from each ear were planted in soil in a bench. After the plants had reached a height of three to five inches, two classes were picked out: one with at least five plants, and these all strong and vigorous, and another with at least five plants but some of these weak. Finally, all of the ears which would normally have been discarded were placed in a *discarded* group. The results obtained with these ears in the field are given in Table 9.

Table 9

RELATION OF GREENHOUSE GERMINATION TEST TO YIELD, 1922

Classes	Discarded Group	Without Weak Plants	With Weak Plants
Number of ears	30	41	29
Stand in field, per cent	76.0	86.3	82.7
Average yield, bu. per acre	22.8	25.5	25.1
Number of ears producing more than expected shown in curve	14	17	14
Number of ears producing less than expected	11	17	12
Number of ears producing same as expected	5	7	3
Average deviation, bu. per acre	+0.7	+0.08	+0.6

An examination of Table 9 shows that a poorer stand was obtained with the discarded group of ears and a slightly less stand from the ears with weak plants, as compared with those without weak plants, but the difference in yield of the individual plants as shown by the average deviation was negligible.

In 1923, a laboratory germination test, using ten kernels from each ear, was made on moist blotting paper. In regard to germination the ears were divided into four classes as follows: *good, good with some mold, fair with mold,* and *poor with mold.* In the *good* class, the kernels showed a strong germination and practically no mold developed on them. In the other classes, the kernels mostly showed the presence of mold. The mold was largely *Fusarium moniliforme* and *Cephalosporium acremonium.* The results obtained in the field with these ears are given in Table 10.

Table 10

RELATION OF LABORATORY GERMINATION TEST TO YIELD, 1923

Classes, as to Germination	Good	Good, With Some Mold	Fair, With Mold	Poor, With Mold
Number of ears	105	29	20	4
Laboratory germination, per cent	99.5	90.4	91.5	77.5
Stand in field, per cent	71.6	66.6	60.2	62.0
Average yield, bu. per acre	22.8	22.3	20.0	23.5
Number of ears producing more than expected shown in curve	45	16	9	3
Number of ears producing less than expected	52	10	8	0
Number of ears producing same as expected	8	3	3	1
Average deviation, bu. per acre	—0.1	+0.9	+0.3	+3.2

Eliminating the *poor* class on account of the small number of ears, a better stand in the field, and consequently a slightly better yield, was obtained with the ears showing a better germination. The difference in the yield of the individual plants, as is shown by the average deviation, was small.

Again in 1924, a laboratory germination test, using ten kernels from each ear, was made on moist blotting paper. The ears were divided into three classes, according to the number of kernels germinating. In the best group, nine or ten of the kernels germinated, in the next group six to eight germinated and in the poorest group only one to five kernels germinated. The results obtained in the field with these ears are given in Table 11.

Table 11

RELATION OF LABORATORY GERMINATION TEST TO STAND AND YIELD, 1924

Number of kernels germinating out of possible 10..	1 TO 5	6 TO 8	9 TO 10
Number of ears	21	58	101
Stand in field, per cent	58.9	74.3	88.3
Average yield, bu. per acre	14.7	17.8	23.0
Number of ears producing more than expected shown in curve	10	26	49
Number of ears producing less than expected	10	30	48
Number of ears producing same as expected	1	2	4
Average deviation, bu. per acre	+0.015	—0.34	+0.09

Again in 1924, the ears showing the lowest germination percentage produced the poorest stands and consequently the lowest yields. As shown by the deviation, there was practically no difference in the yield of the individual plants.

Besides the ear-to-row tests, in 1922 and 1923, larger plantings were made to determine the efficiency of the germination test. Kernels from a large number of ears were germinated and the ears separated by the germination test into good and poor classes. Half of the kernels of the ears from each class were then mixed together in order to obtain composite samples. Then a third class, called for convenience "field run," was obtained by mixing half the kernels from all of the ears. The latter would be representative of the corn commonly planted in the state. These lots of seed were planted in triplicate in the field. The results obtained are given in Table 12.

Table 12

RELATION OF GERMINATION TEST TO STAND AND YIELD

Classes as to Germination

	Good		Field Run		Poor	
	Stand, Per Cent	Yield, Bushels	Stand, Per Cent	Yield, Bushels	Stand, Per Cent	Yield, Bushels
1922	81.2	14.7	72.4	11.6	37.4	7.5
1923	93.7	39.2	90.0	40.5	68.5	32.0

In 1922, the seed corn used was not as good as in 1923. In the former year, many of the ears gave a very poor germination test, while in 1923 most of the ears were good. This condition is evident in the results obtained. As in the ear-to-row tests, a poorer stand and consequently a smaller yield was obtained with the corn showing a poor germination.

Considering all of the germination tests discussed above, it would seem that the following conclusions are safe:

1. Corn showing a low percentage of germination or a lack of vitality in the germination test, will ordinarily give poorer stands and consequently a lower yield even in a region where an excess of seed is planted and the corn thinned to a stand. This decrease, however, is not nearly as much as it would be in a region where only enough seed is planted to produce a stand.

2. No difference in yield can be expected from the individual plants that survive. The plants from the poor ears seemingly produce as much as from the good ears. Consequently, whenever it is possible to obtain equal stands, no material differences in yield can be expected.

SMOOTH AND DENTED EARS

Breeding experiments in recent years have shown that the continued selection of deeply dented kernels results in lower yields. Deeply dented or rough dent kernels usually have a greater length than those from smooth ears.

In 1924, the 180 ears that were used in the ear-to-row tests were selected so that sixty were smooth, sixty were rough-dent and sixty were intermediate or medium. The field results with the ears are given in Table 13.

Table 13

RELATION OF KERNEL INDENTATION TO YIELD AND STAND, 1924

Classes as to Indentation	Smooth	Medium	Rough
Number of ears	60	60	60
Average length of kernels, millimeters	14.1	15.6	16.2
Stand in field, per cent	84.5	81.7	70.0
Average yield, bu. per acre	22.8	20.6	17.8
Number of ears producing more than expected shown by curve	32	21	20
Number of ears producing less than expected	20	29	36
Number of ears producing same as expected	8	10	4
Average deviation, bu. per acre	+1.0	—0.5	—1.3

It is seen that the poorest stand, and consequently the lowest yield, was obtained with the deep, rough-dent kernels. Furthermore, it is seen that the individual plants from the smooth ears produced more than those from the rough ears. The difference in the average deviation is 2.3 bushels per acre in favor of the smooth ears. While only one year's results are available, they are worth while inasmuch as they agree with results which have been obtained elsewhere.

SUMMARY

1. Corn yields in Louisiana are relatively low. There are a number of factors responsible to a more or less extent for these low yields.

2. Many corn grains are internally infected with certain fungous parasites and this fungous infection has often been considered as an important factor in corn production.

3. Four fungi have been described as commonly occurring in corn grains. These are *Fusarium saubinetti, Diplodia seae, Fusarium moniliforme* and *Cephalosporium acremonium.*

4. *Fusarium saubinetti* has not been reported in Louisiana. *Diplodia seae* occurs abundantly in Louisiana, but ears affected with it are seldom used for seed.

5. About 50 per cent of the corn kernels used for seed in Louisiana are infected with *Fusarium moniliforme* and about 30 per cent with *Cephalosporium acremonium.*

6. From three years' tests it would seem that neither *Fusarium moniliforme* nor *Cephalosporium acremonium* has any marked affect on stand or yield in Louisiana.

7. To a certain point, the yield of corn in Louisiana is directly proportional to the stand.

8. From one year's test, the fungous infection of the grains seems to have no effect on the suckering of the plant, nor does the presence of suckers seem to have any effect on the yield of the individual plants. A better stand was maintained with plants that suckered freely.

9. The laboratory germination test is not a good index of what corn will do in Louisiana.

10. Better stands in the field, and consequently higher yields, were obtained with corn that showed well in the germination tests, but the individual plants produced no better than plants from corn that showed a poor germination test.

11. From a single year's test, smooth ears give better stands and higher yields than rough-dent ears. Furthermore, the individual plants produce slightly more.

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A STUDY OF
MICROBIOLOGICAL ACTIVITIES IN SOME LOUISIANA SOILS:
A PRELIMINARY SURVEY

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A STUDY OF MICROBIOLOGICAL ACTIVITIES IN SOME LOUISIANA SOILS:

A PRELIMINARY SURVEY

E. V. ABBOTT

INTRODUCTION

Information which is available regarding the microbiology of the soils of Louisiana is very meager. Within the past few years the importance of a knowledge of the soil conditions affecting the growth of crops has been emphasized as a result of the poor crop yields which have been obtained in the sugar belt of the state. While it is known that plant diseases, insect pests, and other factors are important contributing causes in the difficulties which have arisen, it is also realized that attention must be directed toward a study of soil conditions if a solution to the problem is to be found.

The soils of the sugar section of Louisiana are generally of high natural fertility. Although the use of commercial fertilizers, particularly nitrogen carriers, is profitable on many of these soils, this may be attributed to the unusually heavy drain made upon the soil by the cane crop rather than to natural infertility of the soil. On some of these soils, however, in which the lack of the essential plant food elements in sufficient quantity for crop growth is apparently not the limiting factor satisfactory stands of cane are not obtained. Since the poor yields can hardly be attributed entirely to low soil fertility, some other factor or factors must be involved. Of these may be mentioned (1) poor physical condition of the soil, which might affect not only the development of the root system of the plant, but which would retard favorable biological activities in the soil by means of which food materials are made available to the plant; (2) poor drainage; (3) the presence of toxic substances, either chemical or biological; (4) the presence of harmful microorganisms, or (5) the absence of a desirable microflora.

The present work was undertaken for the purpose of making a general survey of the microbiological activities in some typical Louisiana soils, both alluvial and loessial. It was thought that such information would be of value as a preliminary basis for further soil work.

SOILS

Three alluvial soils from the sugar station, designated as numbers 1, 2, and 3, and one loessial soil from the cotton plots of the experiment station farm, number 7, were included in the work which is reported here. Soils 1, 2, and 3 were in plant cane in 1925, a part of the four year rotation. Number 1 received an application of sodium nitrate equivalent to 36 pounds of nitrogen, acid phosphate equivalent to 36 pounds of P_2O_5, and kainit equivalent to 35 pounds of K_2O. Number 3 received the same amounts of the nitrate and kainit, and number 2 half the amounts of acid phosphate and kainit, in addition to having a crop of sour clover *(Melilotus indica)* turned under in the spring. Soil 7 was cropped to corn and soy beans in 1925 and planted to cotton in 1926.

THE FUNGOUS FLORA

For determining the fungous flora of these soils, permanent sampling stations were established in the field in the rows of cane and cotton. Ten to fifteen small samples were taken at each sampling period to a depth of three to six inches for a composite sample. The composite samples were mixed in the laboratory, and dilution plates poured on Waksman and Fred's synthetic acid agar (11), using the technique suggested by Waksman (7). Five plates were poured for each soil from the 1-10,000 dilution and incubated at 25° C. Cultures were also made at intervals from the 1-1000 dilution. In order to isolate sterile fungi which might be eliminated in making the dilutions, small particles of soil were transferred to plates of both dextrose bean and synthetic acid agar. Transfers were made to agar slants as the colonies sporulated. The genera and species isolated, together with the number of isolations of each, are listed in Table I.

TABLE I

Fungi Isolated from the Soil

	Number of Isolations			
	Soil 1	Soil 2	Soil 3	Soil 7
1. Aspergillus niger van T.	73	18	37	20
2. ” terreus Thom	99	47	97	55
3. ” flavus Link	2	4	10	11
4. ” fumigatus Fres.	3	1	5	72
5. ” flavipes B. & S.	1	4	1	0
6. ” Wentii Wehmer	8	12	3	0
7. ” candidus group TC.	35	30	18	6
8. ” glaucus group TC.	1	0	0	0
9. ” versicolor group TC.	1	1	1	1
10. ” minutus Abbott	1	8	10	11
11. ” humus Abbott	0	0	4	0
12. ” luchuensis Inui	0	0	4	0
13. ” ochraceus group TC.	35	41	31	2
14. ” sp.	19	32	19	22
15. Doubtful Aspergilli	18	21	9	0
16. Penicillium expansum Link em. Thom	74	78	55	48
17. ” pinophilum Thom	91	8	25	36
18. ” chrysogenum Thom	42	22	5	19
19. ” lilacinum Thom	3	5	5	4
20. ” purpurogenum Stoll	1	0	0	1
21. ” italicum Wehmer	9	3	5	9
22. ” rubrum Stoll	1	3	3	0
23. ” luteum Zukal	0	0	3	0
24. ” citrinum Thom	0	0	7	0
25. ” funiculosum Thom	0	0	0	2
26. ” sp.	33	29	16	42
27. Trichoderma koningi Oud.	93	76	106	12
28. ” lignorum (Tode) Harz	6	18	10	20
29. ” flavus Abbott	1	0	2	1
30. ” sp.	2	4	4	14
31. Acrostalagmus albus Preuss.	0	2	3	3
32. ” sp.	6	3	2	3
33. Gliocladium	2	8	9	2
34. Verticillium terrestre (Link) Lindau	2	10	3	2
35. Spicaria violaceum Abbott	1	0	2	2
36. ” sp.	30	30	20	72
37. Fusarium	59	48	40	45
38. Cladosporium herbarum Pers.	21	8	9	16
39. Cephalosporium	10	22	17	5
40. Acrothecium	2	0	1	1
41. Monilia	2	1	7	2
42. Alternaria humicola Oud.	1	4	1	0
43. Phoma	4	9	8	5
44. Chaetomium sp.	0	0	3	0
45. ” crispatum Fuck.	0	0	1	0
46. Hyalopus	1	4	1	2
47. Volutella	1	0	0	0
48. Rhizopus	24	38	24	2
49. Mucor	36	35	34	19
50. Zygorrhynchus	0	2	0	22
51. Oedocephalum	2	1	0	6
52. Sporotrichum	1	0	1	0
53. Botrytis	1	0	1	0
54. Thielavia (?)	0	1	2	0
55. Rhizoctonia	2	2	0	0
56. Marasmius	3	3	0	0
57. Monotospora	0	1	1	0
58. Acremoniella	0	1	0	0
59. Epicoccum	0	0	1	0
60. Pestalozzia	1	0	0	0
61. Brachysporium	1	0	0	0
62. Dematium	0	0	3	0
63. Periconia	0	0	0	2
64. Unidentified Fungi	5	5	1	6

The fungi were identified as to species wherever possible, but this is very difficult among many of the Fungi Imperfecti. Under the "doubtful *Aspergilli*" are included a group of organisms with very small vesicles resembling *Aspergillus minutus* in general morphology. The classification of this group of fungi is discussed in another publication. Most of the unidentified *Aspergilli* which are listed as "*Aspergillus* sp.," are yellow to avellaneous forms which probably belong with the *A. ochraceous* group TC (4). The unidentified *Penicillia* are mostly green forms.

A study of Table I shows that there is no marked difference in the fungous flora of the different soils as determined by the methods used. A large majority of the fungi isolated are saprophytes and these seemed to be rather uniformly distributed. The distribution of the most important groups is brought out more clearly in Table II, in which are shown the total number of isolations of each of the large groups, and the relative percentage of each of the total flora. While the percentages given cannot be considered as being an exact mathematical representation of the distribution of the various groups, they do indicate the relative numbers of each in the different soils.

In both the sugar cane and the cotton soils the *Asper-*

TABLE II

Percent of Different Groups of Fungi
Isolated from Sugar Cane and Cotton Soils

	Soil 1		Soil 2		Soil 3		Soil 7		Ave. % 1, 2, 3.
	Total No. Isolations	%	Total No. Isolations	%	Total No. Isolations	%	Total No. Isolations	%	
Aspergillus	296	34.1	219	30.7	249	35.9	200	31.9	33.6
Penicillium	254	29.1	148	20.8	124	17.9	161	25.7	22.9
Spicaria	31	3.6	30	4.2	22	3.2	74	11.7	3.7
Trichoderma ...	102	11.7	98	13.7	122	17.6	47	7.5	14.3
Fusarium	59	6.8	48	6.9	40	5.7	45	7.2	6.5
Mucorales	60	6.9	75	10.5	58	8.4	43	6.8	8.6

gillus group constituted approximately 30% of the total flora. *A. terreus* and *A. niger* occurred in the largest numbers in the sugar cane soils, followed by the *A. candidus* and *A. ochraceous* groups (A). The other species of the genus occurred in much smaller numbers. In the cotton soil, however, *A. fumigatus,* which was isolated infrequently from the cane soils, predominated, followed by *A. terreus* and *A. niger.* The *A. candidus* and *A. ochraceous* groups were almost lacking in this soil.

The *Penicillia* ranked second in numbers in both of the cane and cotton soils, constituting eighteen to thirty percent of the total flora, with an average of about twenty-five percent. *P. expansum, P. pinophilum,* and *P. chrysogenum* were the most common members of this group, except in soil 2, from which *P. pinophilum* was isolated infrequently. Seven other identified species of this genus were isolated, but they were present in much smaller numbers.

In the cane soils members of the genus *Trichoderma* were third in numbers, comprising about fourteen percent of the total flora. From Table I it will be noted that *T. koningi* ranked with *Aspergillus* terreus as being the most common single species, but considered as entire groups the *Aspergilli* and *Penicillia* were considerably more numerous. In the cotton soil, however, members of this group were only about half as numerous, and *T. lignorum* was isolated more frequently than *T. koningi.* A possible explanation for the larger numbers of *Trichoderma* in the cane soils may be found in the fact that considerable quantities of cane trash, which is largely cellulose, are annually turned into these soils. The *Trichodermae* are known to attack cellulose very vigorously, and it is not uncommon to see the characteristic green growth of Trichoderma on the pieces of dead leaves and stalks of cane lying in the field.

In the cotton soil species of *Spicaria* were more common than those of *Trichoderma,* comprising about twelve percent of the total flora. With the exception of the few cultures of S. violaceum (1) which were isolated, most of these forms belonged to two groups, one grayish-green, corresponding in general with the description of *S. Silvatica,* and the other having a yellowish to rose colored surface, possibly *S. simplicissima.*

Following these genera in order of numbers were the *Fusaria,* comprising six to seven percent of the total, and the *Mucorales,* including the three genera *Mucor, Rhizopus,* and *Zygorrhynchus* was isolated only twice from the cane soils, soil 2, while it was common in the cotton soil. A colony of this fungus usually developed from each clump of the cotton soil which was transferred to agar plates, and pure cultures were often obtained in this manner.

The only parasitic forms isolated were *Marasmius* and *Rhizoctonia* from the cane soils and *Rhizoctonia* from the cotton soil. Both of these fungi play an important part in root rot troubles of sugar cane, and Rhizoctonia causes damping-off of cotton. However, neither of these organisms was isolated frequently, either from the dilution plates or from those directly inoculated with soil. Just why they were not isolated in larger numbers is not apparent, since it is known that they are present in the soils studied and that they grow well on the media which were used. Young cotton plants which were grown in pots in the laboratory by another member of the department, using soil from a plot not far from soil 7, were attacked by *Rhizoctonia* to the extent that most of them died, while *Rhizoctonia* and *Marasmius* have almost invariably been isolated from sugar cane roots affected with root rot. There is also ample evidence in the way of infected plants to show that *Rhizoctonia* particularly is widely distributed in these soils. The failure to isolate these fungi is most probably a matter of technique, yet it seems that with the technique employed they would have been obtained in larger numbers. Both of these fungi are usually sterile as they occur in nature, and it is quite probable that the dilution method of culturing the soil would eliminate them, but they would be expected to develop from the direct soil transfers.

Considering the results as a whole as obtained with the methods used, *Aspergillus* and *Penicillium* constituted over fifty percent of the total number of fungi isolated. These two groups, together with species of *Trichoderma, Spicaria,* *Fusarium,* and the *Mucorales,* comprised ninety percent of the total in both the sugar cane and cotton soils. The remaining ten percent was made up of members of twenty-seven other genera, none of which numbered more than one or two percent of the total. Of these the following genera have been reported from the soil before: *Oedocepahlum, Pestalozzia, Sporotrichum, Hyalopus, Acrothecium, Monotospora, Epicoccum, Brachysporium,* and *Volutella.*

It is of interest to note that the predominating groups in these soils, of which flora studies have not been previously reported, are the same as those found by Waksman (5) (6) in his studies of soils from widely separated localities, and by the author (1) in Iowa soils. While *Alternaria* and *Cladosporium* were relatively more common in the northern soils, and species of *Spicaria* were less common, the general group relationships were the same.

NUMBERS OF MICROORGANISMS

Varying degrees of importance have been attached to the determination of the total numbers of microorganisms in soils by the many workers who have studied this phase of soil microbiology. In some instances a rather close correlation has been found to exist between total numbers of microorganisms and the crop producing power of a soil or other biological processes, while in others such relationships have not been evident. A discussion of these results is not necessary here since Waksman's recent papers (7), (8), give a review of the entire subject. While it would be unwise to draw generalized conclusions regarding the fertility of a soil or to attempt to predict its crop producing power from a study of the numbers of microorganisms in that soil, determination of numbers, as pointed out by Waksman (8), can serve as one means of measuring the general biological condition of the soil.

The soils selected for the present work were numbers 2, 3, and 7, which have been described previously. Soil 1 was not included in this portion of the work since it contains considerably more clay than either 2 or 3, and the

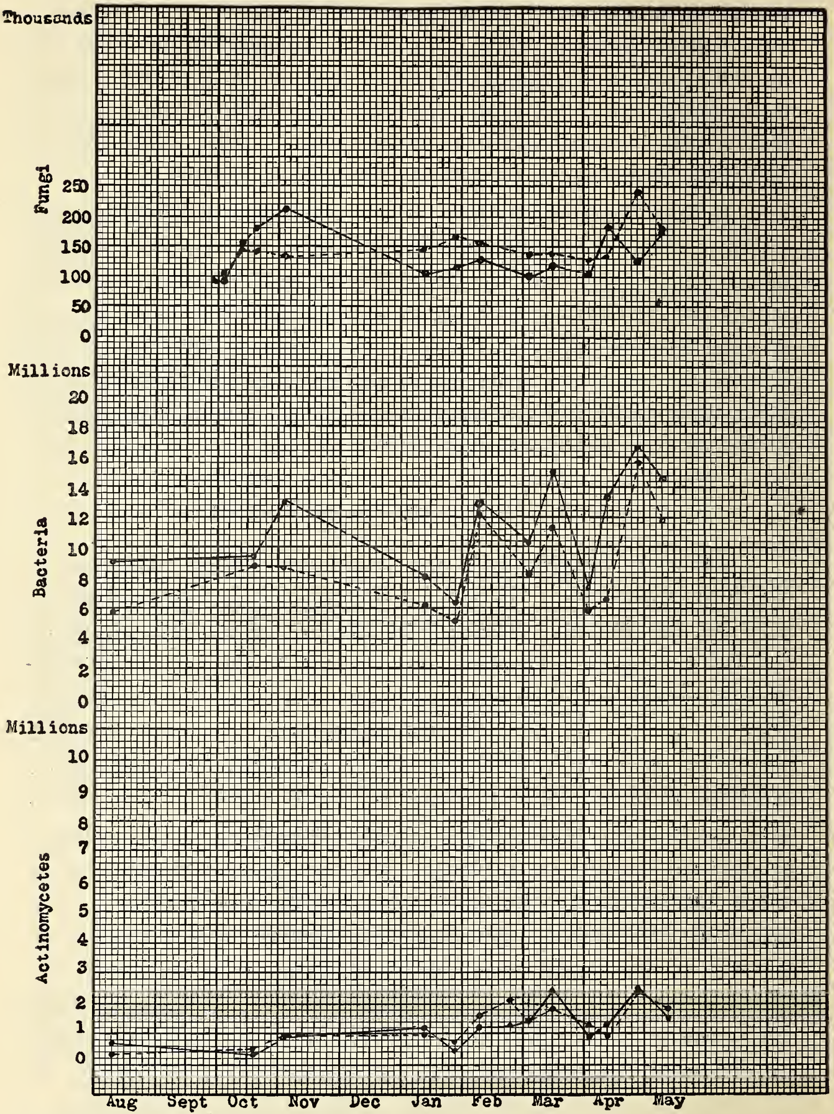

Fig. 1. Showing Effect of Melilotus on Numbers of Micro-organisms in Soil.
Solid line, Soil 2 with Melilotus plowed under.
Broken line, Soil 3, without Melilotus.

results would therefore be less comparable so far as determining the effect of Melilotus is concerned.

Samples were taken and dilutions made as described under the discussion of the fungous flora. Numbers of fungi were determined from the 1-10,000 dilution, and the bacteria and actinomycetes from the 1-100,000 dilution. Counts were made from both smaller and higher dilutions at various times, but the variations from those made from the 1-10,000 and 1-100,000 dilutions were so small as to be insignificant. Waksman and Fred's agar (11) adjusted to a reaction of $_{\mathrm{p}}$H 4.0 was used for culturing the fungi, while Brown's modified albumen agar (7) was used for the bacteria and actinomycetes. Five plates were poured from each dilution and the plates incubated at 25° C. for seven days. The incubation temperatures for the August and October samplings were higher than this, since on these dates the room temperature rose above 25° C., and a cold temperature incubator was not available. In August the room temperature was as high as 35° C., but by keeping ice in the bottom of the incubator below the plates, the temperature of the incubator was kept below 30° C.

TABLE III

Numbers of Bacteria in Soil

Expressed in numbers per gram of air dry soil

Date	Soil 2	Soil 3	Soil 7
1925			
Aug. 8	9,300,000	5,800,000	
Oct. 19	9,500,000	8,800,000	
Nov. 4	13,000,000	8,700,000	
1926			
Jan. 12	8,000,000	6,200,000	3,700,000
Jan. 27	6,300,000	5,200,000	2,900,000
Feb. 10	13,000,000	12,300,000	3,500,000
Mar. 2	10,300,000	8,300,000	
Mar. 15	15,000,000	11,300,000	
Apr. 2	17,300,000	5,900,000	3,000,000
Apr. 12	13,300,000	6,500,000	
Apr. 26			3,300,000
Apr. 28	16,700,000	15,600,000	
May 5			3,500,000
May 10	14,280,000	11,850,000	

TABLE IV

Numbers of Actinomycetes in Soil

Expressed in numbers per gram of air dry soil

Date	Soil 2	Soil 3	Soil 7
1925			
Aug. 8	650,000	370,000	
Oct. 19	280,000	500,000	
Nov. 4	900,000	970,000	
1926			
Jan. 12	1,200,000	980,000	1,220,000
Jan. 27	450,000	700,000	590,000
Feb. 10	1,200,000	1,600,000	1,290,000
Feb. 24	1,250,000	2,100,000	
Mar. 2	1,400,000	1,400,000	
Mar. 15	2,400,000	1,800,000	
Apr. 2	900,000	1,300,000	1,200,000
Apr. 12	1,300,000	950,000	
Apr. 26			1,790,000
Apr. 28	2,500,000	2,400,000	
May 5			1,800,000
May 10	1,500,000	1,800,000	

TABLE V

Numbers of Fungi in Soil

Expressed in numbers per gram of air dry soil

Date	Soil 2	Soil 3	Soil 7
1925			
Oct. 2	96,000	103,000	
Oct. 12	157,000	147,000	
Oct. 19	179,000	141,000	
Nov. 4	212,000	133,000	
Jan. 12	106,000	147,000	
Jan. 27	113,000	167,000	215,000
Feb. 10	129,000	157,000	75,000
Mar. 2	100,000	135,000	
Mar. 15	118,000	137,000	
Apr. 2	103,000	129,000	143,000
Apr. 12	182,000	131,000	
Apr. 28	124,000	241,000	140,000
May 5			175,000
May 10	170,000	179,000	

In Table III are shown the numbers of bacteria, in Table IV numbers of actinomycetes, and in Table V numbers of fungi as determined for soils 2, 3, and 7. A study of

Table III will show that the numbers of bacteria in soil 2, on which Melilotus was turned under, were consistently higher than in number 3, which received an application of nitrate of soda and kainit, but no Melilotus. The differences in the counts for these two soils will be seen more clearly by referring to Figure 1. Although the Melilotus was turned into the soil early in the spring of 1925, the effect on bacterial numbers was still apparent more than a year afterward. It must be kept in mind, of course, that soil 3 received an application of sodium nitrate and kainit and soil 2 acid phosphate and kainit in addition to the green manure, but it is improbable that the effect of these materials would be great enough to account for the differences noted.

In order to determine the immediate effect of turning under the Melilotus crop on the numbers of microorganisms, in 1926 a similar study was made of two soils which received the same treatment as soils 2 and 3 did in 1925, soil 11 corresponsing to number 3, and 12 to number 2. Because of the wet weather which prevailed during the spring of 1926, field work was considerably interfered with, and it was impossible to plow under the Melilotus until later than usual. When this was finally done on April 14 a very heavy growth had resulted. The first samples from these soils were taken for analysis on April 12, two days before the crop was turned under, after which two weeks were permitted to elapse before further sampling was done. By this

TABLE VI

Effect of Melilotus on Numbers of Microorganisms in Soil

Expressed in numbers per gram of air dry soil

Date	Soil 11—Check			Soil 12—Melilotus		
	Bacteria	Actinos	Fungi	Bacteria	Actinos	Fungi
1926						
Apr. 12	10,800*	900	119	11,500	1,100	159
Apr. 27	14,600	2,600	174	55,500	1,600	261
May 4	16,300	2,000	151	50,600	2,600	174
May 10	10,800	1,700	268	25,600	1,400	200

*—Thousands omitted.

time the stalks and leaves of the Melilotus had begun to lose their structure, indicating that decomposition was taking place. The results obtained are presented in Table VI.

By referring to this table, the marked immediate effect which the Mililotus had on bacterial numbers will be apparent. From 11,500,000 organisms per gram of air dry soil on April 12, the numbers jumped to 55,500,000 on April 27. On May 4 the count declined slightly to 50,600,000, and by May 12, when the final samples were taken, a decrease which was almost as marked as the initial increase, had taken place, the numbers having fallen to 25,600,000. In the check soil the numbers at the first sampling on April 12 were practically the same as in the treated soil, 10,800,000. There was a gradual rise on the two succeeding sampling dates, the count being 14,500,000 on April 27 and 16,300,000 on May 4. The final determination on May 10 showed a decrease in numbers to 10,800,000. The increases in this soil were probably due to the increase in temperature, since a gradual rise in numbers in other soils being studied was noted at this time. The final decrease can probably be attributed to a fall in temperature which occurred at that time. The changes in the counts in soil 12 were no doubt also influenced to some extent by the same factor, but the variations are so great as to leave no doubt of the effect of the Melilotus. It would have been desirable to have continued the work in order to determine just how long this stimulation of numbers would be evident, but circumstances made it necessary to bring the work to a close the middle of May.

Turning to a consideration of the numbers of actinomycetes, the figures in Table IV do not show that there was any important effect on this group of organisms, either immediate or residual. In soil 12, as shown in Table VI, there was a gradual rise in the count after the Melilotus had been turned under, but there was a corresponding increase in the check soil, indicating that the rising temperature may have been the determining factor rather than the added organic matter.

The results of the counts of fungi were similar to those for actinomycetes so far as showing any effect of Melilotus is concerned. Beginning in October with 96,000 organisms per gram of soil in soil 2, the numbers rose to a maximum of 212,000 on November 4, and then declined, remaining below the count of the check soil until April 12, when they again rose, only to fall below the check on April 28 and May 10. The differences at each sampling date, however, were small and cannot be considered significant. The numbers in the check soil also fluctuated considerably, apparently irrespective of moisture or temperature, reaching a maximum of 241,000, on April 28. As shown in Table IV, there was a temporary increase in the count when the melilotus was turned under, the counts rising from 159,000 on April 12 to 261,000 on April 27, 174,000 on May 4, and 200,000 on May 10. A count of 268,000 was recorded for the check soil on the latter date.

TABLE VII

Record of Temperatures and Soil Moisture Content

Date	Mean Temp. for 5 days preceding sampling	Soil Moisture Content		
		Soil 2	Soil 3	Soil 7
1925				
Aug. 8	82° F.	8.0	11.8	
Oct. 19	71	17.5	17.5	
Nov. 4	66	20.6	21.2	
1926				
Jan. 12	44	20.1	20.2	21.9
Jan. 27	41	19.7	20.7	22.5
Feb. 10	57	19.3	19.3	21.2
Feb. 24	64	19.5	19.3	
Mar. 2	57	17.5	17.2	
Mar. 15	50	18.4	18.0	
Apr. 2	60	20.4	19.1	19.1
Apr. 12	63	19.8	19.0	
Apr. 26				21.7
Apr. 28	63	19.5	18.5	
May 5	76			16.9
May 10	74	19.5	19.4	
May 12				22.0

In seeking an explanation for the fluctuations in numbers at the different dates of sampling during the entire course of the work, the influence of moisture and temperature suggests itself as a probable determining factor. The temperatures, as recorded at the station, and the soil moisture content at each sampling date, appear in Table VII. Taking soil 2, which may be used as a typical example, it will be seen from Figure 1 that the numbers of bacteria declined rather sharply in January, when the temperature was considerably lower than it was in November, falling from 13,000,000 on November 4 to 6,300,000 on January 27. Since it was impossible to carry on this work in December because electricity was not available for the incubators in the laboratories at the new university, no evidence was obtained of the effect of the first marked drop in temperature which occurred during that month. February was a warm month, and the rise in temperature corresponded with an increase in bacterial numbers from 6,300,000 on January 27 to 13,000,000 on February 10. In March, however, which was wet and cold, the results are less consistent. There was a decrease in the count on March 2 to 10,300,000 organisms per gram of soil, but on March 15, when the temperature was lower, a count of 15,000,000 was recorded. Then on April 2, when the weather was again warmer, a further drop in numbers occurred to 7,300,000. The results from the final samplings on April 12 and 28, and on May 10 correspondended very well with the temperature changes.

The curve representing the changes in the count of actinomycetes generally followed that for the bacteria throughout the period of study, although the degree of fluctuation was much smaller. The curve for fungous numbers, on the other hand, shows no such agreement, and it would be impossible to explain the changes which occurred by the influence of climate. The highest count of fungi, in the cotton soil, for example, was obtained on January 27 when the temperature was lower than at any other sampling date, while the lowest count followed on February 10 when an increase in temperature had again taken place. Brown and Halversen (2) found similar conditions in Iowa soils, and concluded that the fluctuations of fungous numbers from one sampling to the next were apparently unaffected by moisture, temperature, or soil treatment. Their conclusion that bacterial development in soils, during part of the year at least, is controlled by other factors than moisture and temperature, also applied to the results obtained in this work.

Although only six samples were taken from soil 7, which was in cotton, the results obtained, as presented in Tables III, IV and V, are sufficient to give a comparison between it and the sugar cane soils. The minimum count of bacteria recorded for number 7 was 2,900,000 organisms per gram of air dry soil on January 27, and the maximum 3,700,000 on January 12, the latter being less than four-fifths of the minimum count in the cane soils, 5,200,000 in soil 3 on January 27. The numbers remained practically stationary throughout the sampling period from January to May.

The numbers of actinomycetes, on the other hand, showed not only a much higher proportionate count, but also a greater fluctuation from one sampling date to the next. The minimum count for this group, 590,000 per gram of soil, was recorded on January 27, and the maximum of 1,800,000 on May 10. On three of the six sampling dates the actinomycetes counts in the cotton soil practically equalled or exceeded that in the cane soils for the same date, thus showing that this group of organisms constituted a much higher percentage of the total flora in the cotton soil.

The relative numbers of fungi to bacteria in the cotton soils was also much greater in the cane soils. The fungi ranged in numbers from 75,000 per gram on February 10 to 215,000 on January 27. Averaging all of the counts from all three soils, the ratio of bacteria to actinomycetes to fungi in soil 7 was roughly 28-11-1; in soil 3, 56-7-1, and in soil 2, 84-9-1. The bacteria-fungi ratio in each soil is in accord with what would be expected from their reactions, the reaction of number 2, as determined colorimetrically with La Motte standards, being $_{p}$H 7.6-7.9; of number 3, $_{p}$H 7.2-7.4, and of number 7, $_{p}$H 6.4. The ratio of bacteria to actinomycetes was contrary to the generally accepted facts, being lowest in the soil of greatest acidity (2.5-1 in soil 7), and highest in the most alkaline soil (9-1 in soil 2).

NITRIFICATION

The value of a study of nitrification as a means of measuring the general biological condition of a soil and of supplying information regarding the relative fertility of different soils has been pointed out by Waksman (10). His own results as well as those of others which he summarized, show that a rather close correlation exists between the nitrifiying capacity of a soil and its productivity. Since the results supporting this conclusion have been accumulated from the studies of soils in many sections of the country which are of different origin and under different cropping treatment, active nitrification may reasonably be taken as an indication that the soil reaction, aeration, food supply, and other enviromental conditions are favorable for the development of desirable microorganisms.

In the present study of nitrification the soils used were numbers 2, 3 and 7, which have been described, and number 8, adjacent to 7, which received an application of ground oyster shells at the rate of three tons per acre in the spring of 1926. This soil was cropped to corn and soy beans in 1925.

The soil method of studying nitrification was used in the work, following in general the technical suggested by Waksman (9). The soils were collected in the field at a depth of six inches and dried sufficiently to permit passage through a 20-mesh sieve. 100 gram portions of the sieved soil were weighed into tumblers and treated as follows:

Series A: 30 mgm. N as $(NH_4)_2SO_4$
" B: 30 mgm. N as $(NH_4)_2SO_4$ plus 210 mgm. $CaCO_3$
" C: 100 mgm. dried blood
" D: Check, no treatment

The ammonium sulfate was added in solution, and the dried blood was passed through a 40-mesh sieve. The materials were thoroughly mixed with the soil, the moisture content brought to optimum, and the tumblers incubated at room temperature (20-25°C) for fifteen days. At the end of the incubation period nitrates were determined, using the phenoldisulfonic acid method as modified by Harper (3). The results which were obtained are presented in Table VIII. The figures given, which are in terms of milligrams of nitrogen as NO_3 per 100 grams of soil, are the average of three repetitions of the experiment.

Judging from the data in this table, there was evidently very little difference in the nitrifying capacity of the two sugar cane soils studied when either ammonium sulfate or dried blood was used as the source of nitrogen. Slightly more than 5 mgm. of nitrate nitrogen were recorded for each soil from the dried blood treatment. Ammonium sulfate gave 8.48 mgm. in soil 2 and 6.14 mgm. in soil 3. The greater production of nitrates from the sulfate than from the dried blood in these soils is probably accounted for by the fact that their initial reaction is above the neutral point, while the natural buffers in the soil prevented the final reaction from going below pH 6.8, thereby neutralizing to some extent at least the usual depressing effect of the sulfate. The addition of $CaCO_3$ with the ammonium sulfate brought about a marked increase in the amount of nitrate formed in both soils, approximately 20.0 mgm. being present in each case. It also prevented any important increase in the acidity of the soils, the final reading for soil 2 being pH 7.3 and for soil 3 pH 7.1.

In soil 7, the untreated cotton soil, it will be noted that ammonium sulfate was nitrified to a very slight extent, an average of only 1.07 mgm. of nitrate nitrogen being recorded, as compared to 6.14 mgm. in soil 2 and 8.48 mgm. in soil 3. While such an effect is to be expected, it seems that the depression can hardly be explained on the basis of reaction alone since an acidity represented by pH 6.0 is not sufficient to prevent the action of the nitrifying organisms. With the addition of $CaCO_3$ nitrate production was increased nearly ten times. The beneficial efforts of lime on this soil are further shown by the results from soil 8, which received an application of ground oyster shells at the rate of three tons per acre. In this soil ammonium sulfate alone did not depress nitrification, the amount of nitrate formed being slightly greater than that from dried blood, and only 1.7 mgm. less than that formed when the theoretical amount of calcium carbonate necessary to neutralize the acidity was added.

Further evidence of the beneficial effort of lime on the nitrifying organisms in this soil is found in Table VI, in

TABLE VIII

Nitrification in Soils

Expressed as mgm. of NO_3 nitrogen per 100 grams of soil.

	30 mgm. $(NH_4)_2SO_4$					30 mgm. $(NH^4)\ {}^2SO^4$ plus 210 mgm. $CaCO_3$					100 mgm. Dried Blood					Check mgm.
	mgm.	mgm.	Ave. mgm.	Incr. over check	Final pH	mgm.	mgm.	Ave. mgm.	Incr. over check	Final pH	mgm.	mgm.	Ave. mgm.	Incr. over check	Final pH	
Soil 2	11.67	7.77	9.72	8.48	6.8	15.95	24.40	20.18	19.94	7.3	6.28	6.48	6.38	5.14	7.0	1.24
Soil 3	7.50	7.29	7.39	6.14	6.7	15.98	26.60	21.29	20.04	7.1	6.32	6.38	6.35	5.10	7.0	1.25
Soil 7	1.67	2.75	2.21	1.07	6.0	12.11	9.44	10.78	9.64	6.6	5.71	5.67	5.69	4.55	6.3	1.14
Soil 8	8.50	8.51	8.51	6.91	6.8	10.20	10.20	10.20	8.60	7.0	7.79	7.75	7.77	6.17	6.5	1.60

which is recorded the nitrate accumulation in the field. These plots were plowed on February 10, the oyster shells applied on March 2, and the cotton planted in April. No samples were taken during the time the seed bed was being prepared. From 2.0 parts of nitrate per million parts of soil on February 10, the nitrate content rose to 25.8 parts per million on April 26, 28.3 on May 5, and 30.0 on May 12. In the check soil, begining with February 10, the nitrate content for the corresponding dates was 2.31 parts per million, 2.72, 2.88, and 2.91. Here again the changes which have taken place seem greater than would be expected to result from the changes in the reaction of the soils. Three tons of lime per acre caused the reaction to change from pH 6.3 to pH 6.6. Unless some other governing factor was influenced, this small increase in alkalinity brought about a twelve-fold increase in nitrification.

Nitrate accumulation in the field in soils 2 and 3, as shown in Table IX, was apparently governed more largely by the temperature, moisture, and crop growth than by other factors. During August, which was a dry month, the cane made very little growth, a fact which is reflected in the increased nitrate content. Apparently there was not sufficient moisture present in the soil to enable the plant to utilize the nitrates which were being formed. In October the cane made considerable growth and a corresponding decrease in nitrate content of the soil was noted. In December, after the cane had been cut and before cold weather set in, there was a slight rise in nitrate content, followed by a decline to an immeasureable quantity in soil 2 on January 12, and 1.0 parts per million in soil 3. On February 10 an increase to 1.5 and 1.6 parts per million respectively were recorded, after which date there was very little change.

Comparing the nitrifying efficiency of the cotton and cane soils, the latter are seen to have a higher nitrifying power when untreated. With the addition of lime to the cotton soil, however, the results show that the nitrifying organisms are present and that they are of nearly as high efficiency as those in the cane soil. Organic fertilizers such

TABLE IX

Nitrate Accumulation in the Field

Date	Soil 2	Soil 3	Soil 7	Soil 8
1925	ppm.	ppm.	ppm.	ppm.
Aug. 15	18.2	6.8		
Aug. 31	21.0	10.2		
Oct. 12	5.5	7.8		
Oct. 19	2.7	3.6		
Nov. 4	5.8	2.8		
Dec. 3	4.4	3.4		
Dec. 18	7.6	4.1	7.0	
1926				
Jan. 12	0.0	1.0	0.5	0.8
Jan. 27	0.4	1.8	1.1	1.2
Feb. 10	1.5	1.6	2.3	2.0
Feb. 24	1.8	1.9		
Mar. 2	2.7	1.9	3.1	
Mar. 15	2.0	1.5	2.7	
Mar. 24	1.4	1.2	1.0	
Apr. 2	1.7	1.8	0.1	
Apr. 12	1.6	1.9		
Apr. 26			2.72	25.8
Apr. 27	1.5	0.8		
May 5			2.88	29.3
May 10	2.5	1.5		
May 12			2.90	30.0

as blood and probably cottonseed meal, would be expected to become available to plants almost as rapidly in one as in the other. If ammonium sulfate, however, is applied to a soil similar to number 7, the results indicate that it should be accompanied by the use of lime in order to secure the maximum returns from it. Data are not yet available which will show whether the beneficial effect of lime on bacterial activities in this soil will be accompanied by increased crop yields.

NON-SYMBIOTIC NITROGEN FIXATION

For determining the non-symbiotic nitrogen fixing power of these soils, 100 cc. portions of Ashby's mannite solution in 500cc. Erlenmeyer flasks were inoculated with one gram of fresh field soil, incubated at room temperature for fifteen days, and the total nitrogen determined. Checks were inoculated and sterilized in the autoclave, and then placed with the other flasks. The results which are given in Table X are the averages of two repetitions of the experiment.

TABLE X

Non-Symbiotic Nitrogen Fixation in Soils

	mgm N	mgm N	Ave mgm N	Check	Incr. over Check
Soil 1	7.44	8.44	7.94	1.50	6.44
Soil 2	7.50	7.42	7.46	1.09	6.37
Soil 3	7.96	8.47	8.21	1.47	6.74
Soil 7	3.82	3.75	3.78	0.80	2.98

The sugar cane soils, which are found to have the highest total numbers of micro-organisms and the greatest nitrifying capacity, also showed a much higher nitrogen fixing power than did the cotton soil. An average of 6.52 mgm. of nitrogen per gram of soil was fixed by the cane soils, 1, 2, and 3, and 2.98 mgm. by the cotton soil, 7. At the end of the incubation period the flasks inocubated with the cane soils were covered with a heavy, dark brown to black growth, while only a very thin, light brown film had developed in the flasks incubated with the cotton soil.

These results were not unexpected since the writer had difficulty in isolating Azotobacter from soil 7. On mannite agar plates poured from this soil at dilutions as low as 1-10,000, only occasional colonies of Azotobacter would develop, usually one to three colonies on five to ten plates. From the cane soils the Azotobacter counts averaged from 600,000 to 1,000,000 organisms per gram of soil.

SUMMARY

1. In a study of the fungous flora of three alluvial soils cropped to sugar cane and one loessial soil cropped to cotton, it was found that the genera *Aspergillus* and *Penicillium* constitute fifty percent of the total flora. Ninety percent of all the fungi isolated belonged to the genera *Aspergillus, Penicillium, Spicaria, Trichoderma, Fusarium, Mucor, Rhizopus* and *Zygorrhynchus.* Members of twenty-eight other genera were isolated.

2. *Marasmius* and *Rhizoctonia* which are known to be present in the soils studied were isolated infrequently.

3. The total numbers of microorganisms were nearly

twice as great in the cane soils as in the cotton soils. Sour clover (*Melilotus indica*) sown on plant cane and plowed under in the spring, caused an increase in bacterial numbers which was evident throughout the year. The numbers of fungi and actinomycetes did not seem to be materially affected by this treatment.

4. The sugar cane soils were found to have a greater nitrifying capacity than the cotton soil, as measured by the nitrification of dried blood and ammonium sulfate. Plowing Melilotus into the soil caused an initial increase in nitrate accumulation, but apparently did not affect the nitrifying power of the soil.

5. Application of three tons of ground oyster shells per acre to the cotton soil caused an increase in the nitrifying power of the soil.

6. The non-symbiotic nitrogen fixing power of the sugar cane soils was approximately twice as great as that of the cotton soil. Azotobacter were plentiful in the cane soils but were almost lacking in the cotton soil.

ACKNOWLEDGMENTS

The writer is indebted to Dr. C. W. Edgerton for advice and suggestions during the course of the work, and to Prof. A. P. Kerr for making the total nitrogen determinations.

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The Selection of Seed Cane

BY

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BATON ROUGE, LOUISIANA

The Selection of Seed Cane

C. W. Edgerton, W. G. Taggart and E. C. Tims

Seed selection is one of the problems which has interested many of the sugar planters of Louisiana to a considerable extent in recent years. Up until 1924, the Louisiana planters had paid very little attention to seed selection. The usual procedure at planting time was to save the stubble, especially that which was too poor to be cut for the mill, for seed purposes. This practice often resulted in the use of cane for seed on which the various disease organisms had had a chance to accumulate and multiply.

As a result of the crop failure of 1924, upon the advice of the State Experiment Station, a great many of the planters began seed selection work. In the fall of that year hundreds of planters started seed plots ranging in size from an acre or so up to twenty acres and a great many obtained seed from their best fields for their general planting. In the fall of 1925, some of the planters continued this work but the practice was not as general as in the preceding year.

While seed selection is more or less a new problem to the Louisiana planters, it is an old problem in many of the tropical sugar countries. The publications of some of these countries are full of the results of selection work. In some countries the development of seed selection work has practically saved the industry while in others it has undoubtedly increased the production to a considerable extent. In Java, seed selection has developed to such an extent that the growing of cane for seed is as much a business as is the growing of the cane for the mill. Seed is grown at high altitudes where it will develop free of disease and then carried down to the regular sugar districts. In the Fiji Islands, when the Fiji disease threatened to destroy the cane industry, the practice of seed selection brought the industry back to a normal condition. Reports from the Hawaiian Islands show that where attention has been paid to seed selection, crop increases have followed.

There is no reason why the selection of seed should not be just as important a problem with sugar cane as it is with other crops. With the Irish potato, another crop which is propagated vegetatively and is consequently comparable to sugar cane, seed selection has always been an important practice. If the potato grower had consistently obtained his seed from the poorest, most diseased and lowest yielding fields, the potato crop would not be as important today as it is. At present certified potato seed grown under a system

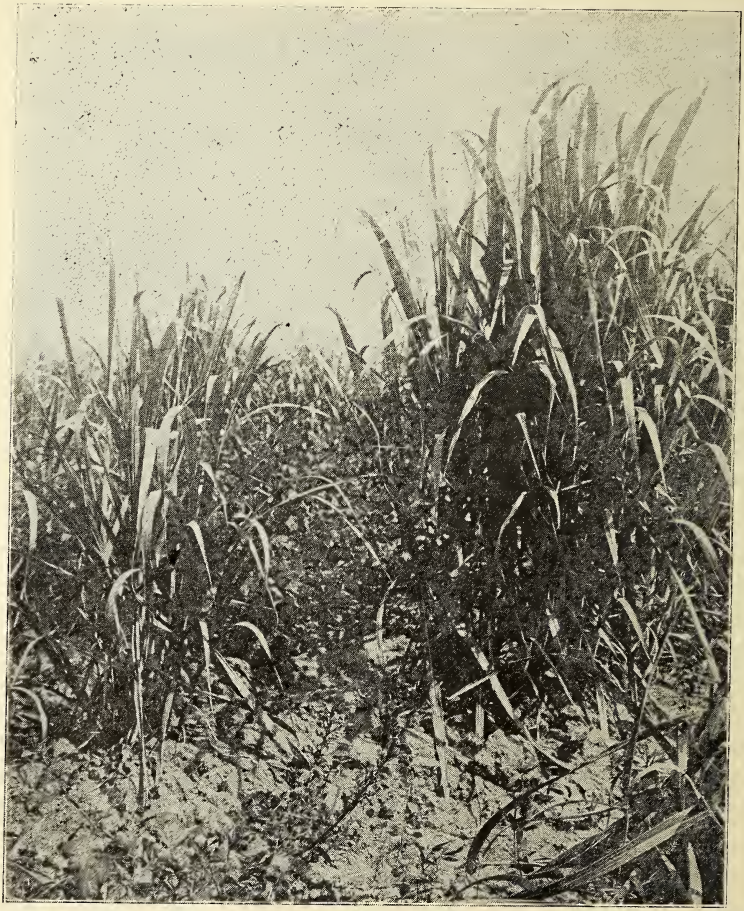

Fig. 1. Two stools of cane growing side by side, one affected with root rot, the other comparatively healthy. The diseased stool should not be used for seed.

of inspection and meeting certain high standards is being used to a very large extent in many regions. The production of this certified seed is becoming as much a business in certain favored sections of this country as is the growing of seed cane in Java.

The object of a considerable portion of the sugar cane selection work in the past seems to have been the obtaining of seed cane as free from certain diseases as possible. The attempts to control the sereh, Figi, and mosaic diseases by the use of disease-free seed are noteworthy examples of this. Other than this, a few investigators have attempted to change or modify the existing varieties by selecting and propagating "bud sports." The results of some of the latter work appeared in the early publications of the Louisiana Sugar Experiment Station. In recent years, the Hawaiian Sugar Planters' Experiment Station has been interested in this phase of selection.

SEED SELECTION AT THE SUGAR EXPERIMENT STATION

The importance of seed selection in Louisiana has been demonstrated during the past few years by the Sugar Experiment Station. The work was originally taken up as a possible means of controlling or reducing the mosaic disease, but it has been enlarged to include also the root rot troubles. After the mosaic disease was introduced and established in Louisiana, it spread rapidly over the State. Because of the quarantine which had been established by the Federal Horticultural Board of the United State Department of Agriculture, the Experiment Station was prevented from bringing in new varieties that might show resistance to the disease. The only promising line of attack at the time seemed to be the selection of resistant or tolerant strains within the commercial varieties that were then being grown.

The surveys and observations that had been made on the mosaic disease showed that all plants of the same variety in a field were not attacked in an equal manner. Some stools of cane would show marked symptoms generally accompanied by a less thrifty appearance, while others would only show slight symptoms with apparently no signs of stunting.

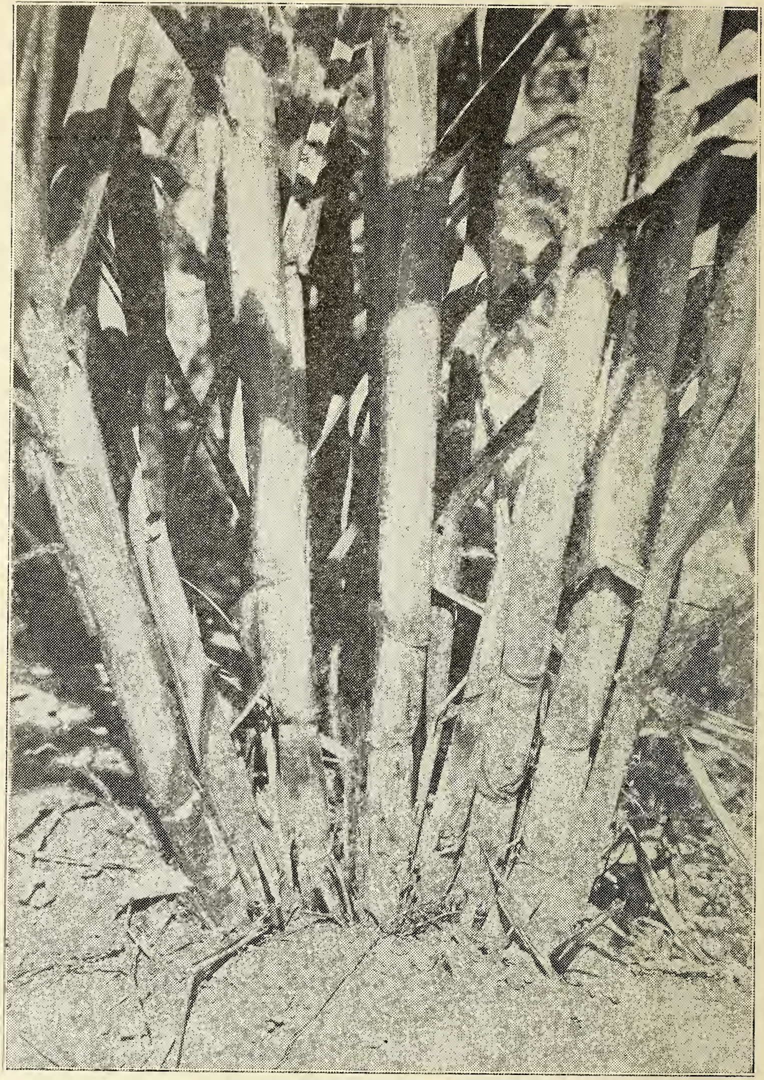

Fig. 2. A good healthy stool of D 74 cane, the type of stool that should be used for planting.

This condition was present even in those fields that had had practically a hundred per cent infection for a number of years. Although the literature on mosaic disease seemed to indicate the opposite, it was decided to select some of the stools showing the least effect of the disease and use the stalks for seed to determine whether the progeny would have the same mild symptoms.

At planting time in the fall of 1920, the different plots of D-74 and Purple Cane on the Sugar Station at Audubon Park in New Orleans were examined very carefully. Stools showing the most thrifty condition with the mildest symptoms of the mosaic were cut for seed. None of the seed selected was free of the disease. Enough seed was obtained of each variety to plant two rows one-half acre (105 ft.) long. As a comparison, a row of unselected cane was planted by the side of the selected.

During the growing season of 1921, the difference between the selected and the unselected rows was very marked. The selected rows had a darker green color, grew more rapidly and stooled better. The difference in growth of the selected and the unselected rows was the cause of considerable comment by the planters assembled at the Summer Field meeting at the Sugar Station in 1921.

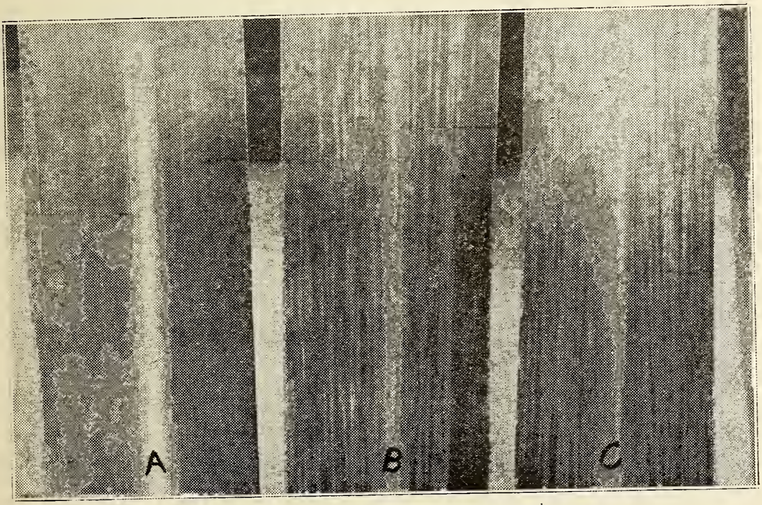

Fig. 3. Average condition of the leaves of the Purple variety from selected and unselected plats; "A" from the selected cane, "B" and "C" from the unselected.

In the fall of 1921, the best stools in the selected rows were again planted in separate plats. In the fall of 1922, this work was continued but each stool used for seed was planted separately.

In the fall of 1923, the Sugar Station was moved to Baton Rouge but enough of the best cane of each variety from the selected plats was moved to plant about 600 feet of each. Although a good stand was not obtained at Baton Rouge with this seed, due to the seed being injured in shipment and by the delay in planting, the cane that did grow was remarkably thrifty and held its bright green color during the record breaking drought of 1924. The comparatively fine growth of this selected cane during such an unfavorable year made such an impression on the planters of the state that a very large number, as has been previously mentioned, selected cane for seed in 1924.

In the fall of 1924, and again in 1925, the best of the cane in the selection plats at Baton Rouge was planted. In the fall of 1925, enough cane was available to plant an acre and a half of each variety. This cane (in 1926) is consequently the result of six years of selection work.

With the establishment of the Sub-Stations or test fields in the sugar district in the fall of 1924, selection work was started on some of them as a major project. A considerable acreage of selected cane of different varieties was planted on Reserve, Raceland, and Glenwood plantations.

At the present time, the results of five years of continuous selection at the Sugar Station and of one year's work at the test stations are available. While the results of the three years' work at Audubon Park have already been published,* they will bear repeating at this time.

RESULTS OF SEED SELECTION AT AUDUBON PARK

In the three years' work at the Sugar Station while it was located at Audubon Park in New Orleans, most attention was paid to the mosaic disease. Both of the varieties that were used in the tests, D 74, and Louisiana Purple, are susceptible to the disease. On the leaves of both varieties, the mosaic appears in the form of light colored stripes, but on the D 74 as the leaves become old, the stripes tend to fade out and appear in the form of light colored, sometimes nearly white, dots or slightly elongated spots. In selecting cane for seed, stools were used which showed the mottling or striping symptoms of the disease in the mildest form. While very little attention was paid to the root rot, it is evident that stools comparatively free of this disease were used. The results of the selection work at Audubon Park are given in Tables I and II.

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* Edgerton, C. W., and Taggart, W. G. Tolerance and Resistance to the Sugar Cane Mosaic. Journal of Agricultural Research 29:501-506. 1924.

TABLE I.

Results obtained from selecting D 74 cane for tolerance to mosaic

Year	Selection	Percentage of mosaic during the season				Yield in tons per acre
		May *	June	July	September	
1921 §	Unselected	40.0		63.0		
	Selected	30.0		28.0		
1922	Unselected	88.7	100.0	100.0	100.0	10.58
	Selected	58.0	94.1	90.0	100.0	14.00
1923	Unselected		96.8	100.0	100.0	8.85
	Selected		85.9	100.0	(‡)	11.90

* The percentages for May are too low on account of the very many small plants on which the mosaic could not be estimated satisfactorily.

§ For 1921 the figures show only the percentages of pronounced mosaic. Most of the data for that year were lost by fire.

‡ A satisfactory count could not be made in September, 1923, since so many of the selected plants showed the disease in so mild a form.

TABLE II.

Results obtained from selecting Purple cane for tolerance to mosaic

Year	Selection	Percentage of mosaic found during the season				Yield in tons per acre
		May *	June	July	September	
1921 §	Unselected	45.0		95.0		
	Selected	25.0		52.0		
1922	Unselected	93.6	100.0	100.0	100.0	17.37
	Selected	69.1	75.9	90.0	(‡)	19.89
1923	Unselected		100.0	100.0	100.0	18.5
	Selected		82.2	100.0	(†)	19.7

* The percentages for May are too low on account of the very many small plants on which the quantity of mosaic could not be estimated satisfactorily.

§ For 1921 the figures show only the percentages of pronounced mosaic. Most of the data for that year were lost by fire.

‡ A satisfactory count could not be made in September, 1922, in the selected plat since less than 10 per cent of the plants showed clear-cut mosaic symptoms.

† A satisfactory count was impossible in September, 1923, in the selected plat on account of the poorly developed mosaic symptoms.

In all of these field tests, the contrast in appearance between the selected and the unselected rows was very striking. The selected rows were darker green in color, the stooling was more pronounced and the individual stalks averaged larger. Although all of the stalks early in the season, when they were growing rapidly, showed mosaic symptoms to some extent, later in the summer and fall, these symptoms became less and less distinct in the selected rows. This was especially true with the Purple variety. Usually from September until the end of the season, it was difficult to make mosaic counts because in many cases the ordinary mosaic characteristics had largely disappeared. On the unselected rows, however, the mosaic symptoms did not disappear as the season advanced. Average appearing leaves from the selected and the unselected rows are shown in figures 3 and 4.

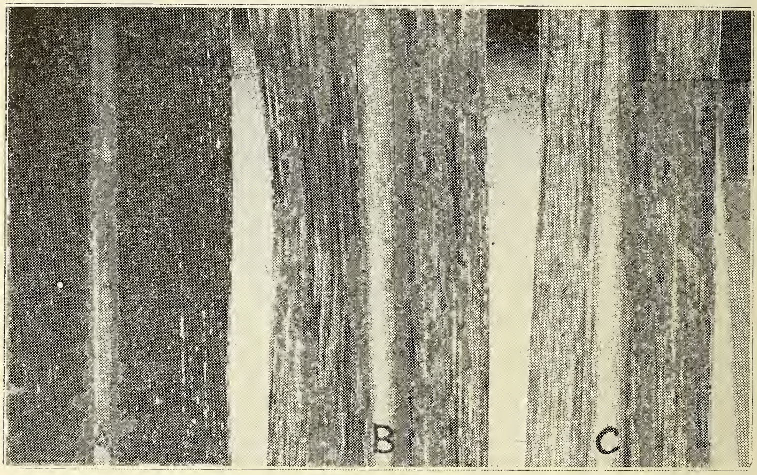

Fig. 4. Average condition of the leaves of D 74 from selected and unselected plats; "A" from the selected, "B" and "C" from the unselected.

In all cases at Audubon Park, the yield of the selected rows was greater than that of the unselected. In some cases, this difference was quite marked, 32 and 34 per cent.

RESULTS OF SEED SELECTION WORK AT BATON ROUGE

The results of the seed selection work at Baton Rouge have been even more encouraging than those obtained at Audubon Park. In 1924, on account of an irregular stand due largely to the injury to the seed from shipping in barrels from New Orleans and to the delay in planting, no attempt was made to obtain the yield. The selected cane was the best on the Station that season and caused considerable comment by many planters who saw it. The leaves remained green and showed the mosaic symptoms in only a very mild form.

In the fall of 1924, the stools showing good characteristics and very little mosaic symptoms were planted separately. Nearly one thousand feet of each of the varieties, D 74 and Purple, were planted. Besides planting a row of unselected, field run cane as a comparison, a row was also

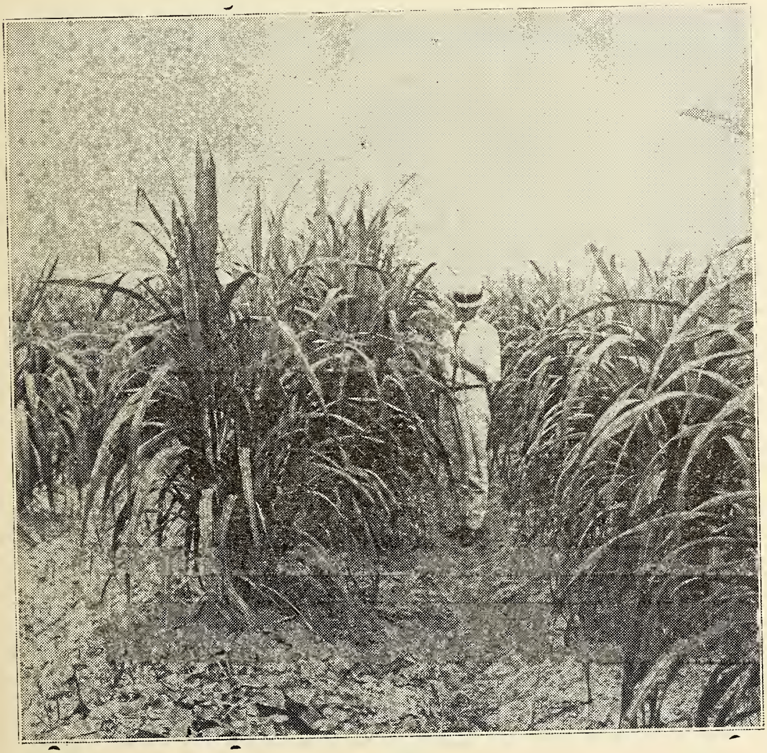

Fig. 5. Selection plat of Purple cane at Baton Rouge in 1924. Row on the left selected, row on the right unselected.

planted with Purple cane that showed pronounced mosaic and root rot symptoms.

The first half of the season of 1925 was very favorable for cane. All the cane germinated well and the young plants grew rapidly, yet even in a season favorable to growth, the difference in appearance and in rate of growth between the selected and the unselected cane was very striking. The unselected rows looked yellow in contrast to the dark green of the selected. This variation in color was visible at a considerable distance from the field. As in previous years, the contrast as to color and mosaic striping was more pronounced on the Purple variety than on D 74. As usual, all of the plants showed mosaic symptoms during favorable growth periods, but on the selected rows these disappeared to a very large extent as the season advanced.

The results obtained at Baton Rouge in 1925 are given in Table III.

TABLE III.

Results of Seed Selection Tests at Sugar Experiment Station Baton Rouge, Louisiana, in Season of 1925

Variety	Manner of Selection	Total Length of Rows (Feet)	Number of Stalks per Foot		Yield per Acre (Tons)	Increase over Checks
			May 4	Oct. 28		
Purple............	Severely affected with mosaic and root rot	200	2.3	1.8	13.68	....
Purple............	Field run not selected	409	1.7	2.9	20.88	....
Purple............	Resistant to Mosaic	1015	1.5	3.2	28.10	7.22
D 74................	Field run not selected	286	0.7	2.3	14.90	....
D 74................	Resistant to Mosaic	943	1.1	2.8	21.97	7.07

As shown in the table, the yield of the selected plats was very markedly superior to the unselected, a difference

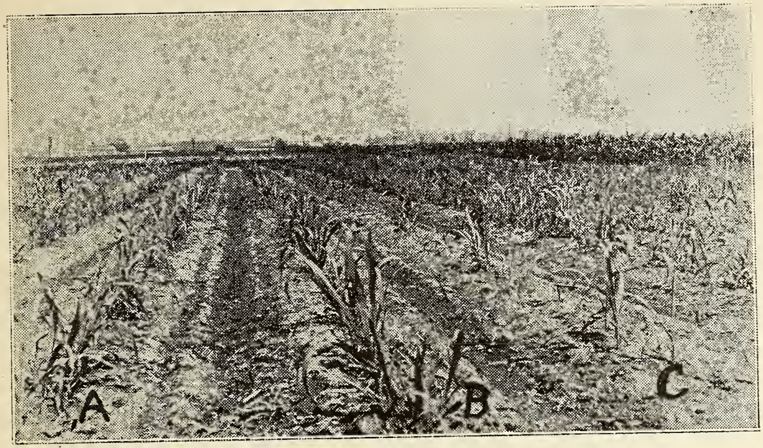

Fig. 6. Selection plat of D 74 cane at Baton Rouge in 1925 early in the season. Two rows on left, "A" and "B" selected; row on right, "C" unselected.

of more than seven tons to the acre in each case. Also, the cane with marked mosaic and root rot symptoms was decidedly inferior even to the unselected field-run cane.

The table also showed that the selected cane had better stooling ability. In each case, the increase of the number of stalks per foot of row from spring until fall was greater in the selected cane. In the row planted with cane badly affected with mosaic and root rot, there were actually fewer stalks at grinding time than in the spring. This bears out many observations made in the Sugar Belt of South Louisiana during the past few years in regard to the effect of root rot. Not only does root rot stunt the growing stalks, but it also prevents stooling and may even cause the death of many suckers that have started to develop.

EFFECT OF SELECTION ON STUBBLE CROP

The stubble cane, as well as the plant cane is improved by seed selection. One of the complaints in the Sugar Belt in the last few years is that the stubble cane does not yield as it did in former days. This seems to a large extent to be due to the greater accumulation in the soil of the root rot parasites. By seed selection the amount of this root rot

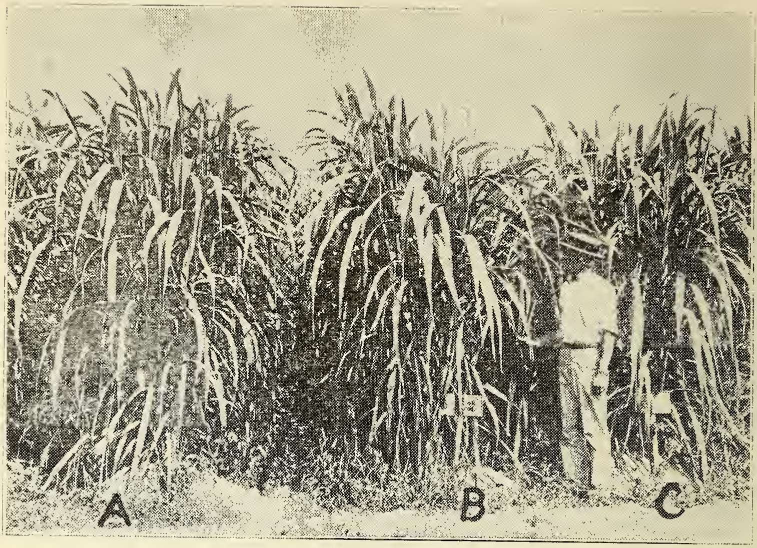

Fig. 7. Selection plat of Purple cane at Baton Rouge in 1925 in mid-season. Two rows on left, "A" and "B" selected; row on right, "C" unselected.

infection is decreased. In the various tests which have been made at the Sugar Station, the stubble from the selected seed has always appeared darker green in color and the plants have shown a greater suckering ability.

TABLE IV.

Effect of Seed Selection on Suckering Ability of Stubble Crop Baton Rouge, Louisiana, in Season of 1926

Variety	Manner of Selection	Total length of rows, ft.	Number of Stalks	Number of Stalks per Foot
Purple	Severely affected with mosaic and root rot	200	299	1.5
Purple	Field run not selected	409	1004	2.45
Purple	Resistant to Mosaic	409	1360	3.33

In table IV is shown the number of stalks per foot in June 1926 in the stubble cane of the Purple selection plat at Baton Rouge. The results of this same plat as plant cane have already been given in table III.

The table shows that the row selected for disease resistance had 36 percent more stalks in the stubble crop than did the unselected row. The table also shows that this row had 2.2 times as many stalks per foot as did the row which was planted with diseased cane. An examination of this cane in the field, or even the figures in the table, will show very plainly what is the matter with much of the Louisiana stubble crops. The practice of using the poorest, most diseased cane for seed is very largely responsible for this condition.

RESULTS OF SELECTION WORK AT TEST STATIONS

With the establishment of the test stations throughout

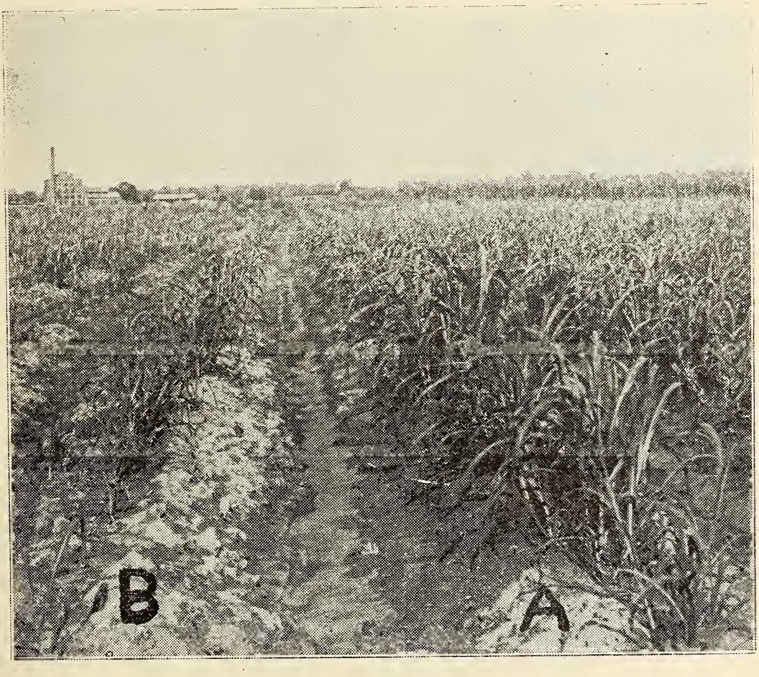

Fig. 8. Effect of seed selection on stubble cane, variety Purple. Row on right "A" selected for resistance and freedom of disease; row on left, "B" from badly diseased cane. Condition on June 21, 1926.

the Sugar Belt in the fall of 1924, selection work was undertaken as one of the projects on three of them. The selection, however, was not as careful as it had been carried on at the Sugar Station. The work was undertaken more as a demonstration, carrying out the recommendations which had been made to the planters during the very disastrous season of 1924. All stools with good growth and stooling characteristics that showed the mosaic in a less pronounced form and did not have the ordinary symptoms of root rot were selected. The man in charge of the work pointed out the desired stools to two cutters who followed him. The stools were cut and hauled out of the field on a mule-drawn sled. By this method cane was selected very rapidly. In most cases, the selection was confined to plant cane but at Reserve, selections were made in both plant and stubble. The results obtained at the three test station are given in table V.

TABLE V.

Results of Seed Selection Tests at Test Stations in Season of 1925

Plantation	Variety	Selection	Total Length of Rows	Number of Stalks per Foot		Yield per Acre (Tons)	Increase over Check
				May 5-8	Nov.		
RESERVE	Purple	Field run stubble	1680	1.3	2.6	20.34	---------
	Purple	Selected stubble	1680	1.3	2.9	29.85	9.51
	D 74	Field run plant cane	1680	0.9	2.6	21.78	---------
	D 74	Selected plant cane	8400	0.9	2.7	24.05	2.27
	D 74	Field run stubble	840	0.6	2.0	15.58	---------
	D 74	Selected stubble	1680	1.0	2.8	29.70	14.12
RACELAND	Purple	Field run plant cane	2454	0.9	2.2	15.24	---------
	Purple	Selected plant cane	7362	0.9	2.8	17.42	2.18
	D 74	Field run plant cane	1636	0.8	2.6	20.00	---------
	D 74	Selected plant cane	8180	0.8	2.7	20.23	0.23
	Striped	Field run plant cane	1636	0.6	2.3	18.15	---------
	Striped	Selected plant cane	8180	0.9	2.5	25.69	7.54
GLENWOOD	Purple	Field run plant cane	1636	0.6	2.3	18.15	---------
	Purple	Selected plant cane	3040	1.2	2.7	22.86	4.61
	D 74	Field run plant cane	1216	0.9	2.9	22.14	---------
	D 74	Selected plant cane	2432	0.9	3.1	22.36	0.22

In all the tests carried on at the test fields in 1925, the selected cane gave a greater tonnage than did the unselected. In six out of the eight tests, the increase in yield was very striking, ranging from 10.8 to 90.6 percent. The tests also show a greater gain with stubble than with plant cane. This was evidently due to the greater amount of root rot in the stubble cane in the fall of 1924.

Another point of interest in the table is the fact that in every one of the tests, there were more stalks at grinding time in the selected than in the unselected. The ability to sucker is of course correlated with yield.

DISCUSSION

In the tests which have been carried on with seed selection, two things seem of particular importance: (1) the increased yields which have been obtained and (2) the development of strains which show a decided tolerance to the mosaic disease.

The increases in yield were evidently due to the lessened effect of the mosaic disease and to a less serious infection with the root rot. Both of these diseases are serious and selection seems to be one of the promising methods of control. On account of the tonnage increases which have been obtained it would seem that it would be to the advantage of every planter to take up seed selection as one of the necessary and important plantation practices.

It has also been demonstrated that it is possible to select plants within a vegetatively propagated variety that show less marked symptoms of the mosaic disease. The strains which have been selected with the Purple variety show the mosaic symptoms in a very mild form. Whether this is due to the plants gradually acquiring an immunity or to the selection of "bud sports" which are more resistant to the disease has not yet been determined. The fact that it is possible to breed up strains within a variety that are tolerant to the mosaic disease is of particular importance.

OCTOBER, 1926 LOUISIANA BULLETIN NO. 196

LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE
AGRICULTURAL EXPERIMENT STATIONS

W. R. DODSON, Dean and Director

BATON ROUGE, LOUISIANA

GROWING PLANTS AS POSSIBLE CARRIERS OF ANTHRAX

BY

HARRY MORRIS and HARLAND K. RILEY

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Growing Plants as Possible Carriers of Anthrax

Harry Morris and Harland K. Riley

Anthrax is perhaps the oldest known infective disease of animals. It is probably alluded to in Exodus as the sixth plague of Egypt. A great many ancient writers gave very good descriptions of the disease. Our knowledge of anthrax was greatly advanced about the middle of the last century when Pollinder published the discovery of the presence of very fine rods in the blood of animals dead of anthrax. This was followed by the classical works of Pasteur, Koch and many others. These investigators proved that anthrax spores would remain in soil or water for a great many years without losing their power to produce the disease if introduced into susceptible animals. Notwithstanding the fact that the study of anthrax has probably contributed more to our knowledge of bacteriology than any other pathogenic micro-organism, a great many points concerning the micro-organism and the disease produced by it remain unsolved.

Anthrax has been known in Louisiana for many years. Certain sections of the State are known as anthrax districts and in these, an outbreak (enzootic) of the disease may occur during the summer months. These districts are usually limited to the rich alluvial Mississippi delta and that portion of the State bordering the Gulf of Mexico. The annual rainfall is about sixty inches, the climate is semi-tropical and the plant growth is luxuriant. The soil conditions are favorable for the presence of spore-bearing micro-organisms such as B. anthracis.

Method of Animal Infection

The question is frequently asked, "How do the anthrax spores get from the soil into the body of the animal?" The usual answer given is that the spores are taken into the digestive tract with contaminated food or water. Some authorities say that the principal carriers of spores are those plants which have been grown on or near places where anthrax carcasses have been improperly disposed of. Some of the spores which are found in the surface of the soil may become attached to plants, by rain or dust, or some of the infected soil may adhere to them as in the case of root crops.

To obtain some definite information on this point of possible forage contamination with anthrax spores a series of experiments was started in 1924 by the Department of Animal Pathology of the Louisiana Experiment Station. The object was to determine the possibility of anthrax spores being carried from inoculated soil on or in forage plants.

Method of Study

Preparation of the soil. Wide mouth glass bottles about eight inches in height were used as containers. Garden soil, with a low moisture content was placed in each bottle to a depth of about two inches. After cotton stoppers had been inserted in the mouths of the bottles they were placed in the autoclave and heated for three hours at eighteen pounds pressure.

Selection of Plants. The plants used in this work included the following: corn, oats, rice, bean, Bermuda grass, (Cynodon dactylon (L) Pers.) and bull grass (Paspalum dilatatum Poir). The seeds were collected from various sources as the work extended over a period of two years time. No special variety of corn was selected and the results were uniform in all tests. The same held true with the selection of oats and rice seed. Several varieties of beans were used with no variation in the results. Soy beans were used in most of the tests as good seed was obtainable at all seasons of the year. Roots of Bermuda grass and bull grass were collected from the campus.

Planting. After the soil had been sterilized and cooled the seeds were planted in the usual manner, one to three grains of the various plants were dropped into each container and then pushed into the soil to the depth of about an inch. The beans were planted in the same manner. In the work with some of the grasses the roots were similarly imbedded in the soil. Sterile glass rods were used to push the grains and roots into the soil.

Inoculation of the soil. The soil was inoculated with a watery suspension of virulent anthrax spores prepared as follows: about fifty cubic centimeters of sterile water were added to each agar slant culture of anthrax spores. The suspension was well agitated to prevent excessive clumping of the spores and then transferred to the bottles containing the soil by means of sterile pipittes. Great care was taken to prevent the spores from splashing on the sides of the containers and thus become a possible source of infection to the growing plants.

The soil was inoculated either at the time of planting or before the plants appeared through the surface of the ground. Enough of the suspension was added to each container to thoroughly moisten the soil. This usually amounted to about twenty-five cubic centimeters depending to some extent on the amount of moisture already in the soil. In the tests with rice additional water was used to insure the proper development of the plants. The seeds were not sterilized before planting.

Controls. In each series of tests a certain number of uninoculated containers was run as controls. Sterile water was used to moisten the soil to insure development of the various plants.

Examination of Plants for Anthrax Spores

Technique. When the plants had grown to a height of from three to five inches they were examined for the presence or absence of anthrax spores. After removing the cotton plug from the bottle a plant was cut off with a sterile knife near the surface of the soil, removed with sterile forceps and then cut with fine scissors into sections measuring from one-half to one inch in length. The sections of each plant were placed in a sterile dish separately and care was taken to prevent contact between them. In sectioning a plant great care was exercised to prevent carrying infection on the instruments from one part of the plant to another. In part of the work a different pair of sterile scissors was used in making each section, while in other cases the same instrument was used for a plant but it was placed in alcohol and thoroughly flamed following each operation.

Each section of the plant was put in a test tube of liquified nutrient agar, agitated and a plate was poured in the usual manner. It was not found necessary to make additional dilution plates. The plates were then incubated at a temperature of 37.5° C. and examined regularly for the presence of anthrax colonies. The pathogenicity of a number of these colonies was proven by animal inoculations. Guinea pigs were used in these tests. The section of the plant nearest the ground was cultured first and each other section successively. The following tables give the results in both the inoculated soils and controls. Plus and minus will be used as descriptive terms meaning the presence or absence of anthrax colonies.

TABLE I. TESTS WITH CORN

No. of Plant	Section of Plant													
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	+	+	+	−	−	−	−	+	+	−	+	+	+	−
2	+	+	+	−	−	−	−	−	−	−	−	−	−	
3	+	+	−	−	−	−	−	−	−	−	+	−	−	
4	+	+	+	+	−	−	−	+	−	+	+	−		
5	−	−	−	−	−	−	+	−	+	−	−	−		
6	+	+	+	+	+	+	−	+	+	−	+	+	−	
7	−	−	+	+	−	−	−	−	−					
8	+	+	+	−	−	−	+	−	+					
9	−	−	−	−	−	−	−	−	−					
10	−	−	−	−	+	+	−							
11	+	−	+	−	+	+	+	−						
12	+	−	−	−	−	+								
13	+	+	+	−	−	−	+							
14	+	−	−	−	−	−	−	+						
15	+	+	+	−	+	+	+	−						
16	+	−	+	+	+	−	+	+	+					
17	+	−	−	+	−	−	−	−	+					
18	+	−	−	+	−	−								
19	−	+	+	−	−	−	−	+						
20	+	+	−	−	+	−	−	−						

21	+	—	—	+	—	—	—	+						
22	+	+	—	—	—	—	—	—						
23	+	+	—	—	+	—	—	+						
24	+	—	—	—	+	—	—	—						
25	+	+	—	—	—	—	+	+	+					
26	—	—	+	—	+	—	—	+	—					
27	+	—	—	+	—	+	+	+	—					
28	+	+	—	—	—	—	—	+	+					
29	—	—	+	—	+	—	—	—	—					
30	+	—	—	—	+	—	—	—	—	+				
31	+	—	+	+	—	—	—							
32	+	+	—	—	—	—	—	+						
33	+	—	—	—	—	+	—	—						
34	—	—	—	—	—	—	—	—						
35	+	+	—	—	—	—	+							
36	+	—	—	—	—	—	—	—						
37	+	—	—	+	—	—	—	+						
38	+	+	—	—	—	+	—	+						
39	—	—	—	—	—	—	—	—	—					
40	+	—	—	+	—	—	+	—						
41	+	—	—	—	—	+	—							
42	—	+	**Not Cultured**				—	+	+					
43	+	+					—	—	—					
44	—	+					—	+	—					
45	+	—					—	+	—					
46	+	—					—	—	+					
47	—	+					—	—	—					
48	—	—					—	—	—					
49	+	—					—	+	—					
50	+	—					—	—	+					
51	—	—	—	—	—	—	—	—	—	—	**Controls**			
52	—	—	—	—	—	—	—	—	—	—				
53	—	—	—	—	—	—	—	—						
54	—	—	—	—	—	—	—	—						
55	—	—	—	—	—	—	—	—						
56	—	—	—	—	—	—	—	—	—					
57	—	—	—	—	—	—	—	—	—	—				
58	—	—	—	—	—	—	—	—	—	—				
59	—	—	—	—	—	—	—	—	—	—				
60	—	—	—	—	—	—	—	—	—					
61	—	—	—	—	—	—	—	—	—					
62	—	—	—	—	—	—	—	—	—					
63	—	—	—	—	—	—	—	—	—					
64	—	—	—	—	—	—	—	—						
65	—	—	—	—	—	—	—	—	—	—				
66	—	—	—	—	—	—	—	—	—	—				
67	—	—	—	—	—	—	—	—	—					

The above table shows that ninety-two percent of the corn plants grown in inoculated soil were carrying anthrax spores. The micro-organisms were found on all parts of the plants from the stems to the tips of the leaves. Eighty percent of the plants examined showed the presence of anthrax on the first inch and one-half of the stems while the tips of the leaves showed anthrax present on about sixty percent. The number of anthrax colonies developing in the cultures varied from one to fifteen with the greatest number on the lower parts of the plant. The controls were all negative.

TABLE II. TESTS WITH OATS

No. of Plant	Section of Plant												
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	+	+	+	+	—	—	—	—	+				
2	+	+	—	+	—	—	—	+	—	+	+	+	
3	+	+	—	—	—	—	—	—	—	+			
4	+	+	+	—	—	+	+	+					
5	+	+	+	+	—	—	—	—	+	—	—	+	
6	+	+	+	+	—	+	—	—	—	+	+	+	+
7	+	+	+	+	+	—	—	—	—	—	—	+	
8	+	+	+	—	—	—	—	+					
9	+	+	—	+	+	+	+						
10	+	+	+	+	—	+	+	+					
11	—	—	—	+	+								
12	—	—	—	—	+	+							
13	—	+	+	+	+	+	+						
14	+	+	+	—	+	+	+	—					
15	+	+	+	+	—	+							
16	+	+	+	—	+	+	+	—					
17	—	—	—	—	—	—							
18	+	—	+	—									
19	+	—	—	+	—								
20	—	—	—	—	—								
21	+	+	—	+	+	—							
22	—	—	—	—	—	—	—						
23	+	—	—	—	—	—							
24	+	—	—	—	—	+	+	+					
25	—	+	—	—	—	+	—	+					
26	+	+	—	—	+	—	+	+					
27	+	—	—	—	+	—	—	+					
28	—	—	—	—	—	—							
29	+	—	—	—	—	—	+						

30	—	+	—	—	+	+							
31	+	—	—	—	+	+	+						
32	—	—	—	—	—	—	—						
33	+	+	—	—	+	—							
34	+	+	—	—	—	—	—	+					
35	—	+	+	—	—	—	+						
36	—	—	—	—	—								
37	+	—	+	+									
38	—	+	+	+	+								
39	+	+	—	—	+	+	+						
40	—	+	—	—	+	+	+						
41	—	—	+	—	—	+	—	—					
42	+	—	+	—	—	—	+						
43	+	—	—	—	—	+							
44	—	—	—	—	—	—							
45	+	+	—	—	—	—							
46	—	—	—	—	—	—	—	—	**Controls**				
47	—	—	—	—	—	—	—	—					
48	—	—	—	—	—								
49	—	—	—	—	—	—	—						
50	—	—	—	—	—	—	—						
51	—	—	—	—	—	—							
52	—	—	—	—	—								
53	—	—	—	—	—	—	—						
54	—	—	—	—	—	—							
55	—	—	—	—	—	—							
56	—	—	—	—	—								
57	—	—	—	—	—								
58	—	—	—	—	—	—							
59	—	—	—	—	—	—							
60	—	—	—	—	—								
61	—	—	—	—	—								
62	—	—	—	—	—								
63	—	—	—	—	—	—	—						
64	—	—	—	—	—	—	—	—					
65	—	—	—	—	—	—	—						

Eighty-four percent of the oats plants grown in anthrax inoculated soil showed the presence of anthrax spores on some portion of the plant. The distribution of the spores over the plants was about the same as in the corn experiments except that the percentage of spores at the top of the plants was practically the same as that found near the ground, about seventy-five percent. The number of colonies developing in the cultures was practically the same as found in the tests with corn. The controls were all negative.

TABLE III. TESTS WITH RICE

No. of Plant	A	B	C	D	E	F	G
	Section of Plant						
1	+	—	—	+	+		
2	—	—	—	+	—	—	
3	—	—	+	—	+		
4	+	—	—	—	—		
5	—	—	—	—			
6	—	—	—	—	—		
7	—	—	—	—			
8	—	—	—	+			
9	—	—	—	—	—		
10	—	—	+	—	—		
11	+	+	—	—	+		
12	—	—	—	—	—		
13	—	—	—	+			
14	+	—	—	+			
15	—	—	—	+	—		
16	—	+	—	—	+		
17	—	—	—	—	—		
18	+	—	—	—	—		
19	—	—	—	—	—		
20	—	—	—	—	—		
21	—	—	—	—	—		
22	—	—	—	—	—		
23	+	—	—	—			
24	—	—	—	—	—		
25	+	—	—	+	+		
26	—	—	—	—	—		
27	—	—	—	—	—		
28	—	—	—	—			
29	+	—	—	—	+		
30	—	—	—	—	—		
31	—	+	—	—	—		
32	+	—	—	—	—		
33	—	—	—	—	—		
34	—	—	—	—	—		
35	—	—	—	—	—		
36	+	—	—	+	+		
37	—	—	—	—			
38	+	—	—	—	—		
39	—	—	—	+	—	—	—
40	—	—	—	—	+		
41	—	—	—	—	+		
42	—	—	—	—	—		
43	—	—	—	—	—		
44	—	—	—	—	—		
45	+	—	—	—	—		
46	—	—	—	—	—		
	Controls						
47	—	—	—	—	—	—	
48	—	—	—	—	—		
49	—	—	—	—	—		
50	—	—	—	—	—		
51	—	—	—	—			
52	—	—	—	—	—	—	
53	—	—	—	—	—	—	
54	—	—	—	—	—	—	
55	—	—	—	—	—	—	
56	—	—	—	—	—	—	
57	—	—	—	—	—	—	
58	—	—	—	—	—	—	
59	—	—	—	—	—	—	
60	—	—	—	—	—	—	
61	—	—	—	—	—	—	
62	—	—	—	—			
63	—	—	—	—			
64	—	—	—	—	—		
65	—	—	—	—	—		
66	—	—	—	—	—		
67	—	—	—	—	—		

Fifty percent of the rice plants cultured showed the presence of anthrax spores. The percentage of spores present at the base and top of the plants was practically the same. Very few colonies developed in the cultures. This decrease in infection as compared to the other plants might have been due to the flooding of the soil with water following germination to insure proper growth of the rice. The controls were negative.

TABLE IV. TESTS WITH BEANS

No. of Plant	Section of Plant																
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	+	+	+	+	+	+	+	+	+	c+	c+	+	+	+	+		
2	+	+	+	+	+	+	+	+	—	+	c+	c+	+	+	+	+	
3	+	+	+	+	+	+	+	+	c+	c+	+	+	+	+	+	+	+
4	+	+	+	—	—	—	c+	c+	+	+	+	+					
5	+	+	+	+	+	—	+	+	+	c+	c+	+	+	+	+		
6	+	+	+	+	+	+	+	+	c+	c+	+	+	+	+			
7	+	+	+	+	+	—	+	+	c+	c+	+	+	+	+			
8	+	+	+	—	—	—	+	+	+	—	—	a					
9	+	+	+	+	—	—	+	c+	c+	+	+	+					
10	+	+	+	+	+	+	+	c+	c+	+	+	+	+				
11	+	+	+	—	—	+	+	+	c+	c+	+	+	+	—			
12	+	+	—	—	—	+	+	+	c+	c+	+	—	—				
13	+	+	—	—	+	+	+	c+	c+	—	—						
14	+	+	+	+	+	+	+	+	c+	c+	+						
15	+	+	+	+	—	—	+	c+	c+	+	+	+	+				
16	+	+	+	+	—	+	+	c+	c+	+	+	+					
17	+	+	+	+	—	—	+	c+	c+	+	+	+					
18	+	+	+	+	+	+	+	+	c+	c+	+	—					
19	+	+	—	—	+	+	—	c+	c+	+	+	+	—				
20	+	—	+	+	—	+	+	c+	c+	+	+	+					
21	+	+	+	+	—	—	+	+	c+	c+	+						
22	+	+	+	+	+	+	—	c+	c+	+	+	—	—				
23	+	+	—	—	—	+	+	+	c+	c+	+	+	—				
24	+	+	—	—	+	+	+	+	c+	c+	+	+	+	+			
25	+	+	+	—	+	+	+	c+	c+	+	+						
26	+	+	—	+	+	+	+	c+	c+	+	+	+	+				
27	+	+	+	—	—	+	+	c+	c+	+	+	+					
28	+	+	—	+	+	—	+	c+	c+	+	—	—	+				
29	+	+	+	—	+	—	+	+	c+	c+	+	+	+				
30	+	+	+	—	—	+	+	c+	c+	+	+	+					
31	+	—	+	+	—	+	+	+	c+	c+	+	+					
32	+	+	+	—	+	+	+	+	c+	c+	+	+					
33	**Stems Not Cultured**						+	+	c+	c+	+	—	—				
34						—	+	c+	c+	+	+	+					
35							+	c+	c+	+	+	+	+				
36							+	c+	c+	+	+	+	+				
37							+	+	+	+	+	+	—	—			
38							—	—	c+	c+	+	+	+				

39						—	+	c+	c+	+	+	+				
40							+	c+				—	—	+	+	+
41	—	—	—	—	—	—	—	c—	c—	—	—	—	—	**Controls**		
42	—	—	—	—	—	—	—	—	c—	c—	—	—	—	—		
43	—	—	—	—	—	—	—	—	—	c—	c—	—	—	—		
44	—	—	—	—	—	—	—	—	c—	c—	—	—	—	—		
45	—	—	—	—	—	—	—	—	c—	c—	—	—	—	—		
46	—	—	—	—	—	—	—	—	—	c—	c—	—	—	—		
47	—	—	—	—	—	—	—	—	—	c—	c—	—	—	—		
48	—	—	—	—	—	—	—	—	—	—	c—	c—	—	—		
49	—	—	—	—	—	—	—	—	—	c—	c—	—	—			
50	—	—	—	—	—	—	—	c—	c—	—	—	—	—	—		
51	—	—	—	—	—	—	—	—	c—	c—	—	—	—	—		
52	—	—	—	—	—	—	—	—	c—	c—	—	—	—			
53	—	—	—	—	—	—	—	—	—	c—	c—	—				
54	—	—	—	—	—	—	—	—	c—	c—	—	—				
55	—	—	—	—	—	—	—	—	c—	c—	—	—	—			
56	—	—	—	—	—	—	—	—	c—	c—	—	—				

NOTES { a—Cotyledons had dropped off.
c—Cotyledons.

One hundred percent of the bean plants grown in inoculated soil showed the presence of anthrax spores on the plants. The spores were present on all parts of the plant up to the second set of leaves. The cotyledons were covered with spores in every case. A large number of colonies developed in the cultures. The controls were negative.

TABLE V. TESTS WITH BERMUDA GRASS
(Cynodon dactylon (L.) Pers.)

No. of Plant	**Section of Plant**															
	A	B	C	D	E	F	G	**H**	I	J	K	L	M	N	O	P
1	+	+	—	—	—	—	—	—	+	—	—	—	—	—	—	—
2	+	+	—	+	+	—	—	—	—	—	—	—	—	—	—	—
3	—	—	+	+	—	—	—	+	—							
4	—	—	—	—	—	—	—									
5	—	+	+	+	+	—	—	+	+	—	—	—	—	—		
6	—	+	+	—	—	—	—	—	—							
Controls																
7	—	—	—	—	—	—	—	—								
8	—	—	—	—	—	—	—	—								
9	—	—	—	—	—	—	—									
10	—	—	—	—	—	—	—	—	—	—	—					

TABLE VI. TESTS WITH BULL GRASS (Paspalum dilatatum Poir.)

No. of Plant	Section of Plant						
	A	B	C	D	E	F	G
1	+	—	+	—	—	+	—
2	+	+	—	+	+		
3	+	+	—	+			
4	—	+	—	—	—	—	
5	+	+	—	—	+	+	
6	+	—	+	—	—	—	—
Controls							
7	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—
9	—	—	—	—	—		
10	—	—	—	—	—	—	
11	—	—	—	—	—		

The results of the work with Bermuda grass and bull grass as shown in Tables V and VI were unsatisfactory. The roots of these grasses were planted a number of times but proper growth, under laboratory conditions was obtained only in a very few cases. The tests are not extensive enough to draw conclusions, but are consistent with the other results.

LOCATION OF ANTHRAX SPORES

As the work advanced the question arose whether the spores were carried on the surface of the plant or in the plant tissues. A series of tests was run to obtain information on this point. Corn, oats and beans were grown in inoculated soil and the same technique was used in sectioning the plants as in the previous work. The sections were placed in a 1-1000 solution of bichloride of mercury for five minutes, washed in sterile water three times, macerated and cultured. Every alternate section of the plant was not sterilized and was used in a control series to prove the presence or absence of the spores. In the work with beans the colyledons were sectioned and one-half was sterilized while the other was used as a control.

The results obtained were negative in all cases or in other words anthrax colonies did not develop in the cultures made from macerated plant tissue following sterilization of the surface of the plant. The controls or unsterilized portions gave positive results, indicating the presence of anthrax spores on the surface of the plant. After examining thirty plants the results obtained seem to indicate that anthrax spores were carried from the soil on the surface of the plant and not in the plant tissue.

Effect of Rainfall on the Presence of Anthrax Spores

The question also arose during the work concerning the effect of the heavy semi-tropical rains upon the presence of spores on the plants and the possibility of rain washing off these spores. Twenty-five tests were conducted along this line. The plants were grown in inoculated soil and after a certain development they were washed daily for three days. The water was applied either with an atomizer or by allowing the water to drop from a pipitte. Care had to be observed to prevent splashing. The plants were then examined for spores.

The results seem to indicate that the number of spores on the plants was reduced by washing but not completely eliminated. A great number of colonies developed in the cultures made from corn and bean plants following the application of water.

SUMMARY AND CONCLUSION

1. The results indicate that, under laboratory conditions anthrax spores are carried from artificially inoculated soil by germinating and growing plants.

2. The results indicate that anthrax spores were carried from inoculated soil by germinating and growing corn, oats, rice and bean plants.

3. The results from a few tests show that anthrax spores were carried from the soil by Bermuda grass and bull grass.

4. The anthrax spores were carried from the soil on the surface of the plant and not in the plant tissue.

5. Washing the plants with water for three consecutive days only removed a portion of the anthrax spores.

The results obtained in this work should again remind the livestock men of Louisiana of the great importance of sanitation in the control of anthrax and especially of the necessity for complete destruction of anthrax carcasses to prevent soil inoculation and subsequent spread of the disease through forage contamination. Once a soil is inoculated with anthrax spores it is always a menace to the live stock industry. But soil inoculation can be prevented in Louisiana by the prompt and complete destruction of all anthrax carcasses.

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W. R. DODSON, Dean and Director

BATON ROUGE, LOUISIANA

INVESTIGATIONS
ON THE
SUGAR CANE DISEASE SITUATION
IN 1925 AND 1926

BY

C. W. EDGERTON and E. C. TIMS

Investigations on the Sugar Cane Disease Situation in 1925 and 1926

C. W. EDGERTON AND E. C. TIMS*

INTRODUCTION

Due to a combination of causes including disease attack, borer infestation, weather conditions and other factors, the sugar industry of Louisiana has been in an acute condition for a period of several years.

Following the crop failure of 1924, a bulletin (Louisiana Bulletin 191) was published by the Louisiana Agricultural Experiment Station describing the general situation and presenting a discussion of the causes. On account of the various theories and ideas held by many planters and others interested in the sugar industry, it seemed necessary at that time to put on record the actual condition and to give the best information available as to the causes. While some of the conclusions in the bulletin were somewhat different from those prevailing in many sugar countries, they were based on a knowledge of the Louisiana sugar industry and a knowledge of the diseases as they actually occurred in the state. The developments of the past two years have demonstrated the soundness of the general conclusions.

After two more years of unsatisfactory crops, it seems desirable to again put on record the general conditions and to give the results of the investigations which have been conducted during this period. A considerable portion of the money and forces which have been available for sugar work has been concentrated on the field problems. During the last half of 1926, the investigations on the disease problems have also been materially broadened by the special appropriation which the State Legislature made for sugar work.

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*In obtaining the data for this bulletin, the authors have been assisted by Mr. P. J. Mills, assistant in Plant Pathology, and C. S. Holton, student assistant.

CROP SITUATION

The condition of the Louisiana Sugar Industry can perhaps best be understood by giving the statistics of the crop for a number of years. Such statistics, as compiled from the Yearbooks of the United States Department of Agriculture are given in Table 1. In the table are shown, for each year, the actual tonnage used for the manufacture of sugar, the acreage, the yield per acre and the average amount of sugar obtained from a ton of cane. The statistics taken together form a fairly satisfactory index of the prosperity or the lack of prosperity of the industry at any particular time.

In studying the table, it should be borne in mind that during the years of 1924 and 1925, more cane was used for syrup making than is normally used and this brought down the actual production of sugar to a certain extent. In 1924, 9,280,118 gallons of syrup were made in the sugar belt of Louisiana and in 1925, 5,960,942 gallons, this being considerably more than the normal output.

TABLE 1

Cane Yields in Louisiana, 1911-1926

Year	Area cut for Sugar	Yield per acre, tons	Sugar made, tons	Sugar per ton, pounds
1911 . .	310,000	19.0	352,874	120
1912 . .	197,000	11.0	153,573	142
1913 . .	248,000	17.0	292,698	139
1914 . .	213,000	15.0	242,700	152
1915 . .	183,000	11.0	137,500	135
1916 . .	221,000	18.0	303,900	149
1917 . .	244,000	15.6	243,600	128
1918 . .	231,200	18.0	280,900	135
1919 . .	179,900	10.5	121,000	129
1920 . .	182,843	13.6	169,127	136.1
1921 . .	226,366	18.5	324,431	155.2
1922	241,433	15.6	295,095	156.2
1923 . .	217,259	11.1	162,023	135.8
1924 . .	163,000	7.6	88,000	144
1925 . .	221,000	16.5	198,000	108
1926*. .	159,800	6.9	67,854	123

*Preliminary estimate.

An examination of the statistics in Table 1 shows that for at least four years, 1923-26 inclusive, the sugar crops of Louisiana have been very unsatisfactory. During this period, sugar was produced at a loss and the planters who were fortunate enough to break even were comparatively few. In 1923, the yield of cane per acre was very low, only 11.1 tons; in 1924, the yield per acre was still lower being only 7.6 tons; in 1925, the yield per acre was about normal but the sucrose content of the juice was extremely low; in 1926, the yield per acre was the lowest on record being only 6.9 tons with the sucrose content of the juice also comparatively low.

While the statistics in the table tell the story of the condition of the Louisiana Sugar Industry at the end of 1926, for an understanding of the causes, it is necessary to have a knowledge of the growth conditions during the different years.

The season of 1925 started off with great promise. As a result of the dry season of 1924, the seed planted in the fall was extremely good. Very little of it was injured by borers and the red rot infection was only slight. Good growing conditions came earlier than usual in the spring of 1925 and the cane had an early start. The cane grew very rapidly during the summer months and everything pointed towards a large crop. The early promise, however, was ruined by an extremely heavy infestation of borers combined with growing conditions in the fall which prevented the cane from maturing. Warm rainy weather in the fall permitted a late growth which was suddenly stopped by a killing frost. Not only were the stalks riddled by borers but the juice was extremely low in sucrose. The condition of the cane at grinding time was so poor that a considerable amount of it was never taken to the mill.

As a result of the heavy borer infestation, the cane used for seed in the fall of 1925 was very poor. This was the beginning of a bad start for 1926. The winter of 1925-26 was also very wet and water stood on many of the fields for considerable periods. The spring of 1926 did not open for nearly a month later than that of the previous year. Following these conditions, the cane came up very slowly in the season of 1926 and in most cases very poor stands were obtained. The cane also grew very slowly during the spring and early summer months.

In order to obtain accurate information on the condition of the cane and the diseases present, a careful survey was made of the whole sugar belt during August and the early part of September, 1926. A number of plantations in each parish were selected and these were examined carefully. Information was obtained in regard to the stand, height of the plants, drainage, fertilization, root growth, severity of the mosaic and root rot diseases and the damage caused by root eating insects and animals. The actual condition of the cane as to stand and height of the plants is given in Table 2. These data represent the average of all fields examined. By height of plants is meant the distance from the ground to the terminal bud. At that time of year, the cane should have been from five to six feet tall.

TABLE 2

Stand and Height of Cane in the Louisiana Sugar Belt, August-September, 1926

Variety	Plant or Stubble	No. of Fields	Average Stand, Per cent	Average Height of plant; inches
D. 74	Plant	47	51%	34 in.
D. 74	Stubble	54	64	31
Purple	Plant	31	62	36
Purple	Stubble	44	56	27
Striped ...	Plant	7	59	31
Striped ...	Stubble	10	67	32
P. O. J. 234	Plant	36	74	51
P. O. J. 234	Stubble	9	73	49
Cayanna ...	Plant	10	67	41

An examination of the Table shows that on an average there was but slightly more than half a stand of cane in 1926. Furthermore, in midsummer the cane averaged less than three feet high which is but slightly more than half of what it should have been. The condition of the cane varied somewhat in different sections. In the river, Bayou Lafourche and lower Teche parishes, the cane was very poor, while in the western and northern parishes it was considerably better. While in a few places, there were some fields of very good cane, the growth conditions in the Louisiana cane fields, taken as a whole, during the summer of 1926 were very bad.

In September and later until frost, growth conditions were much improved. In many places the cane grew very rapidly during September and October, and, like the preceding year, it was caught by a frost while it was still in a comparatively green condition. This late growth again resulted in a low sucrose content of the juice at grinding time.

The cane used for seed in the fall of 1926 was comparatively free of borers and, consequently, was much better than that used in the fall of 1925. With good winter conditions, much better stands of cane can be expected in the spring of 1927.

CAUSES OF CROP CONDITION

A determination of all the factors which have played a part in producing the poor sugar crops of the past few years is not an easy problem. It seems very definite, however, that the short crops have not been due to a single cause but have resulted from the combined effect of a number of things. Among the factors which have acted to a greater or less degree in an adverse way upon the sugar crops include (1) weather conditions, (2) cultivation and drainage conditions, (3) cane borer infestation, and (4) the attack of cane diseases. While this bulletin is intended to discuss the recent work on cane diseases, it is necessary to keep some of these other factors in mind. Cane diseases are influenced by the weather and soil conditions and a knowledge of the latter helps to understand the effect and the importance of the former.

EFFECT OF WEATHER CONDITIONS

Weather conditions have exerted an influence on the Louisiana cane crops in two ways: first, in a direct way by providing conditions unfavorable for the growth of cane; and, second, indirectly by providing conditions favorable for the development of cane diseases and parasites.

The effect of the weather conditions on the crops of 1923 and 1924 have already been discussed in the bulletin noted above. The year of 1923 was one of the wettest on record and was unfavorable for cane growth; while 1924 was the driest year on record and the crop of that year was almost a failure.

The weather conditions of 1925 and 1926, while different from those of the preceding years, were also not favorable for the cane crops. Three things should be mentioned in regard to these seasons.

In both 1925 and 1926, the weather conditions were such that the cane continued to grow through the fall months and was in an immature green state at the time of the first killing frost. This immature condition resulted in a low sucrose content of the juice. In both years in some sections of the state, the sucrose content was so low that sugar could not be manufactured economically.

A second unfavorable weather condition was the excessive rainfall during the winter of 1925-26. Nearly twenty-five inches of rain fell during the months of January, February and March of 1926, this being about eleven inches more than normal. As a result of this heavy rainfall most of the sugar fields remained watersoaked through a greater part of the winter. On many of the fields there was standing water for considerable periods. Even on those plantations where the drainage practices were of the best, it was impossible to remove the excess water.

The effect of winter rainfall on the cane yield of the following season has recently been discussed by McDonald[1] of the United States Weather Bureau. He stated that a high winter rainfall, especially if concentrated in March, is harmful to the following crop. To show the relation between winter rainfall and crop yields the rainfall in inches for the months of January, February and March, and the number of tons of cane harvested per acre for the period from 1911 to 1926 are given in Table 3. The rainfall in the table represents the average for ten stations in the sugar belt. The figures for 1911 to 1924 were taken directly from McDonald's paper while those for the last two years were obtained from the United States Weather Bureau Reports. A study of the Weather Bureau records seemed to indicate that the rainfall for the three dormant winter months was more important than for that of March alone.

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[1] McDonald, W. F. A Study of weather influences on sugar cane production in Louisiana. Reprinted as a separate from The Planter and Sugar Manufacturer, May 29, 1926-July 17, 1826, inclusive.

TABLE 3

Relation of Rainfall in Winter to Yield of Cane

	Rainfall, inches			Total Jan.-Mar.	Average yield per acre, tons
	Jan.	Feb.	Mar.		
1911	3.22	1.20	3.82	8.24	19.0
1912	4.92	4.56	5.92	15.40	11.0
1913	5.32	3.05	3.92	12.29	17.0
1914	0.99	5.91	5.23	12.13	15.0
1915	6.99	5.99	2.94	15.92	11.0
1916	5.20	2.14	0.91	8.25	18.0
1917	6.03	3.46	3.70	13.19	15.6
1918	4.75	2.81	2.58	10.14	18.0
1919	7.22	6.20	3.82	17.24	10.5
1920	6.30	3.96	2.61	12.87	13.6
1921	2.29	1.77	3.05	7.14	18.5
1922	4.75	4.17	9.60	18.52	15.6
1923	3.25	3.06	5.38	11.69	11.1
1924	6.67	5.44	2.33	14.44	7.6
1925	6.59	2.26	1.52	10.37	16.5
1926	8.20	2.79	13.41	24.40	6.9
Average	5.16	3.67	4.42	13.26	14.05

An examination of the table shows that high yields have followed winters with low rainfall and low yields have followed winters with high rainfall. This relationship is brought out better by the graphs in figure 1. The graph made with a solid line shows the acre yield in tons for each year while the graph made with a broken line shows the rainfall in inches in January, February and March. If this figure is studied closely, it will be found that there are only two years, 1922 and 1923, that do not follow the rule. The yield in 1922 was somewhat higher

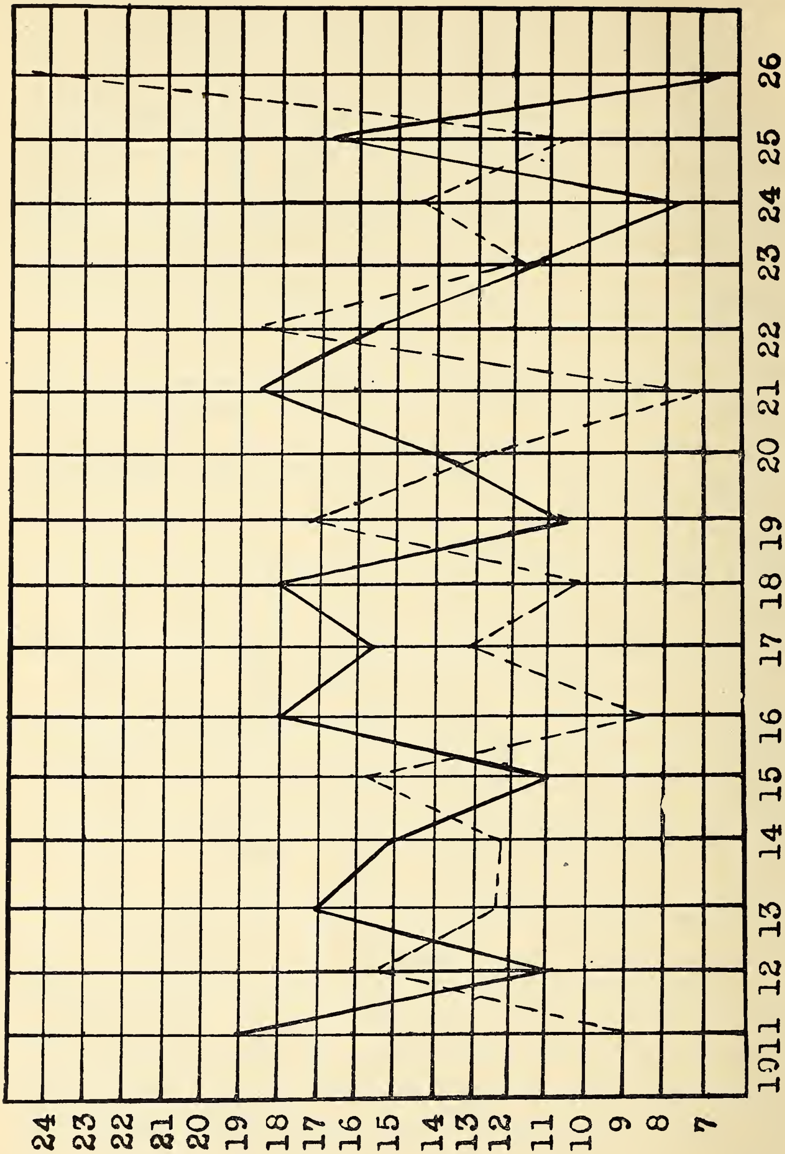

Figure 1. Curves showing relation between winter rainfall and cane yields. Solid line represents yield in tons per acre from 1911 to 1926. Broken line represents rainfall in inches in January, February and March in the same period.

than would be expected while that of 1923 was lower. The low yield of 1923 can readily be accounted for by the heavy summer rainfall and high borer infestation of that year.

The relation brought out between winter rainfall and the acre yields of cane is really remarkable and shows very clearly one of the effects of weather. It would seem that a knowledge of the winter rainfall might help in predicting the following crop. Providing other conditions are more or less normal, a rainfall in January, February and March of much over fourteen inches would suggest a reduced yield while a rainfall less than that would suggest a satisfactory yield. It is evident that the very heavy rainfall during the winter of 1925-26 was partly responsible for the low yield obtained in the fall.

The third weather condition having an effect on the cane crop was the hurricane which passed directly through the sugar belt on August 25 and 26, 1926. Certain varieties of cane, especially P. O. J. 979 and D 74, were broken severely by this storm. Other than the breakage, the storm did not seem to have any adverse effect on the sugar crop. As a matter of fact, most of the cane in the sugar belt showed a more rapid growth after the storm than it had at any time during the early part of the season. Many fields which had been growing very slowly during the spring and early summer grew very rapidly during the fall months after the storm. A possible explanation of this will be considered later in this bulletin in the discussion of the root rot complex.

CULTURAL PRACTICES

Just what effect the existing drainage and cultural practices have had upon the present cane situation is difficult to state with any degree of accuracy, yet it is evident that they have had some influence. During the past few years, on account of financial and labor conditions, many planters have not been able to keep up their drainage ditches and to cultivate and fertilize the cane in a way that they would like. It is worth while, to at least mention a few of the things which have had an influence on the cane crop.

If excessive rainfall, as has been discussed on a previous page, has a serious effect on the cane crop, it is evident that the actual loss occurring on any plantation will depend to a considerable extent upon the efficiency of the drainage system. If the water can be carried off quickly, the loss will be much less than if it is allowed to stand on the soil for some time. A satisfactory drainage system under Louisiana conditions would include three things. The main ditches should be at least one foot lower than the quarter drains and close enough together to quickly take off the water that drains in them. The quarter drains should be at least three or four inches below the middles and should always be kept open so that the water will quickly run out of the furrows. And lastly, the seed cane should be placed high enough in the ridges so that it is up above the furrows. It is evident that if these conditions are not met, the soil around the planted cane will remain saturated for periods long enough to hurt the crop.

In the survey made during the summer of 1926, an attempt was made to find out the drainage conditions in the different parts of the sugar belt. On the report for each field, the drainage was marked *excellent, good, fair* or *poor*. At that time of the year it was not possible to determine how deeply in the ridge the cane had been planted. The only things that could be observed were the drainage ditches and the quarter drains. Upon the efficiency of these depended the score given on the report. Reports marked fair or poor showed an unsatisfactory condition. The survey showed that of the 248 fields examined, 74 had unsatisfactory drainage.

While it is recognized that in certain sections of the sugar belt, it would be very difficult to provide a drainage system that would satisfactorily take care of a rainfall like that of the winter of 1925-26, it must also be recognized that the prosperity of the sugar industry depends to a considerable extent upon the effectiveness of the drainage conditions. Drainage and the root rot problem are inseparable. This not only applies to D 74 and the so-called native canes but to any other variety as well. While it is true that certain varieties are more resistant to root rot troubles than others, there is no variety that will not show a reduced yield under unsatisfactory drainage conditions.

It is not necessary to more than mention some of the cultural practices that have had an influence upon cane growth. Most planters realize that in order to reduce expenses, soil preparation and cultivation have in many cases not been as thorough as in previous years. Among other things, the soil has often been plowed too shallow, the hoe gangs have been decreased and cane has not always been scraped at the proper time.

Cane fertilization has also been decreased to a very considerable extent during the past few years. The survey made during the summer of 1926 showed that on the 248 fields examined, fertilizer had been applied to only 44. While it is true that the fertilizer applied in 1926 seemed to have had little or no effect on the resulting crop, it is, nevertheless, true that high tonnages cannot be expected if no attempt is made to keep up the fertility of the soil.

Another thing brought out in the survey is worthy of mention. The use of *Melilotus indica* on the cane crop has been recommended for a number of years, yet this legume had been planted on only 19 of the 248 fields of cane observed in the survey. Certain planters, to be sure, have not been thoroughly convinced that a winter cover crop of Melilotus is advisable, yet very few of those who do believe it, had it growing on their cane in 1926.

EFFECT OF CANE BORER

The cane borer had a serious effect on the crops of both 1925 and 1926 though not in the same way. Possibly the heaviest borer infestation on record occurred in 1925. Officials of the Bureau of Entomology of the United States Department of Agriculture estimated the loss in that year as more than 30 per cent. On the other hand, the borer infestation in 1926 was comparatively light and the loss during the growing season was very moderate. The borer, however, did have a serious effect on the crop of 1926. The cane used for seed in the fall of 1925 was so badly infested that it was difficult to find a joint that did not contain from one to several borers. This poor condition of the seed was partly responsible for the poor stands of 1926.

EFFECT OF SUGAR CANE DISEASES

That the diseases of cane have been important factors in the cane situation is readily admitted by all. There are a number of cane diseases in Louisiana but the ones which have had the most influence on the crops are the red rot, the mosaic and the group of troubles which are classed together under the name of the root rot complex or the growth failure complex.

The red rot reduces the sucrose content of the standing cane and also decreases the germination of the planted cane. The red rot fungus enters the standing cane through borer holes. Poor stands very frequently occur as a result of planting borer infested cane that is infected with red rot.

The mosaic disease reduces the green coloring matter in the leaves and prevents to a more or less degree the growth activities of the plants. The chief effect of this disease is the reduction in tonnage.

The troubles classed together under the term, root rot complex or growth failure complex, prevent the roots from functioning normally. The roots fail to grow satisfactory or rot severely. Poor germination and slow growth follow root rot attacks.

The investigations which have been carried on during the past two years at the Experiment Station on these and some other diseases which seem of interest, are discussed in the following pages. For a general discussion of these diseases, the reader is referred to the bulletin (Louisiana Bulletin 191) published in 1924.

Root Rot Complex or Growth Failure Complex

The term, *root rot* or *root disease,* as it is used in various sugar producing countries does not refer to a single disease nor does it always have a definite meaning. In general, it usually is applied to a failure of the plants to grow satisfactorily on account of the failure of the root systems to function normally. This failure of the plants to grow as they should, seems to be the only common characteristic of plants affected with root rot, as the term is used in various countries. As there are many things influencing the growth of the plants and the activities of the root system, the terms, *root rot complex* or *growth failure complex,* seem more explanatory than root rot. *Growth failure complex* is the more satisfactory term of the two to apply to the various root troubles and is being adopted in Hawaii. In Louisiana as the term *root rot* is in such common usage, it is more convenient to retain the name either unchanged or in the form of *root rot complex.*

In Louisiana, the most common symptom of root rot is the failure of the plants to grow satisfactorily, especially during the spring and early summer months. The plants are quickly hurt by adverse growing conditions and respond but slowly to good growing conditions. Attempts to stimulate the plants by the application of fertilizers are usually unsuccessful. The leaves lose their dark green color and become pale green or even a light yellow, and in later stages, the margins and tips may even die and become brown. The roots of an affected plant are usually much shortened and very frequently both the main roots and the laterals are much reduced in numbers. In severe cases, the root system is so deficient that a whole stool may be pulled from the ground with but very little difficulty.

From the nature of the symptoms, it can readily be seen that anything which affects the root system, becomes one of the factors in root rot. As the growth and functioning of the roots are influenced by a number of such factors, these together constitute the root rot complex. It can also be seen that the factors producing a root rot condition in one country or in one district may not necessarily be the same as in another.

From a close study of the root rot conditions in Louisiana during the past four years of poor crops, it is clear that there are a number of causal factors concerned which are worthy of consideration and further investigation. The ones which have been studied or upon which investigations are being started are listed below. It should not be inferred that these are the only factors which are influencing the root rot situation.

(1). The presence of toxic substances in the soil.
(2). The improper ratio of the mineral elments in the soil.
(3). The pitting of the roots by soil animals.
(4). The activities of nematodes.
(5). The relation of parasitic fungi.

I. THE PRESENCE OF TOXIC SUBSTANCES IN THE SOIL

That soils may contain substances toxic to plant growth is generally recognized. How important this may be in the root rot situation in Louisiana is not known but it is a question which should be studied. There are certain peculiarities of the local situation that would suggest that toxic substances may be of some importance.

Root rot is always worse following a wet winter. A saturated condition of the soil without suitable under drainage would tend to increase the amount of any toxin that might be in the soil. Furthermore seepage water would be more apt to be troublesome than rain. Seepage water is constantly bringing up substances in solution which are largely left in the upper layers of the soil. If the toxic substances are deposited as the soil dries out, then the severity of root rot would be greater in years when seepage and rainfall in the preceding winters were much in excess of normal. This has been proven to be the case.

Furthermore, if toxic substances occur in the soil, these would tend to be washed out by satisfactory under drainage or by storms with heavy rainfall. It is the opinion of a great many of the successful planters that a heavy rain, especially if accompanied by wind, after the cane is laid by in the summer will start it to growing. This condition occurred in 1926. The hurricane in August carrying twelve to fourteen inches of rain, apparently had a very beneficial effect on the growth of the cane plants.

The question of toxic substances is a very difficult one to study but an attempt is being made to obtain some data on it and work on this subject will be carried on during the coming year.

II. THE IMPROPER RATIO OF MINERAL SALTS IN THE SOIL

In certain countries, the root rot problem is very closely associated with an abundance of the salts of certain mineral elements, such as magnesium, manganese, iron and aluminum. In the Hawaiian Islands, a root rot condition produced by an excess of manganese is common in certain of the acid soils. In the United States, the root rot of corn in the corn belt is associated very closely with an improper ratio of manganese, nitrogen and phosphorus compounds.

Whether the root rot situation in Louisiana is associated to any degree with the chemical elements present in the soil is not clear at present. This is another phase of the subject which should be studied and upon which investigations will be started as soon as possible.

III. PITTING OF ROOTS BY SOIL ANIMALS

An interesting phase of the sugar cane root rot problem is the injury to the roots produced by insects and other small animals. This injury usually shows in the form of small, more or less circular pits extending directly into the roots. While these pits are at first clean cut showing little or no color, later the tissue around them takes on a reddish or brownish color.

The possible relation of the pits to the root rot situation in Louisiana was first brought out by the work of Rands. In 1924, Rands[2] stated that the pits which were produced by a small snail, *Zonitoides arboreus* (Say), permitted the entrance of the various root-rotting fungi. In the same year, Brandes made a report of Rands' work to the First Conference of the International Society of Sugar Cane Technologists held in Honolulu and in the report of the meeting,[3] the following statement occurs: "The root-rot of Louisiana was described by Dr. E. W. Brandes of the U. S. Department of Agriculture, Washington, D. C. He stated that R. D. Rands, also of the Department of Agriculture, had found the cause of the root trouble in Louisiana.—A cable had just been received from Dr. K. F. Kellerman of the Department in Washington, permitting the release of information, then in press, purporting to establish the cause of root-rot of sugar cane in Louisiana." In a later report, Rands[4] also included two other organisms, species of centipedes, as being capable of producing the pits. In this later report, Rands also reviews the few earlier articles from Java and Hawaii that mentioned injuries produced by root eating animals.

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[2] Rands, R. D. "Snails as predisposing agents of sugar cane 'root disease' in Louisiana." Journal of Agric. Research 28:969-970. 1924.

Recently two other articles in which root pitting has been discussed have been published by Matz[5] and Van Zwaluwenburg.[6] Matz in Porto Rico claims that pits are made by nematodes while Van Zwaluwenburg claims that in Hawaii the principal animals concerned are centipedes and springtails. The statement is also made that the injury resulting from the pits is only of minor importance in the root rot problem in Hawaii.

On account of so much difference of opinion in regard to the pitting, an attempt has been made during the past year to obtain as much information as possible on this subject. Two lines of work seemed to be important: (1) to find out what organisms are responsible for the pitting and (2) to ascertain whether the pits injure the cane to any serious extent and to determine how important the pits are in permitting the entrance of root rotting fungi. The first part of the work, to find out the organisms responsible for the pitting, has been taken up by Dr. W. E. Hinds and

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[3] Lee, H. Atherton. Sugar cane diseases. Digest of the Proceedings of the First Conference of the International Society of Sugar Cane Technologists. pp. 9-12. 1924.

[4] Rands, R. D., "Root disease of sugar cane in Louisiana." United States Department of Agriculture, Department Circular No. 366. May, 1926.

[5] Matz, Julius. Root knot on sugar cane in Porto Rico. Phytopath. 15: 559-563. 1925.

[6] Van Zwaluwenburg, R. H., "Injury to cane roots in Hawaii by soil animals other than nematodes." Reports of the fifth annual meeting of the Association of Hawaiian Sugar Technologists. pp. 18-25. 1926.

Dr. Herbert Spencer of the Entomology Department of the Experiment Station. The second phase of the work was undertaken by the Plant Pathology department and the information obtained up to the present time is presented in the following pages.

DISTRIBUTION OF ROOT PITTING IN LOUISIANA

In the survey made in the sugar belt in the summer of 1926, an examination was made of the cane roots in every field visited. Roots were dug up from a number of different stools and a rough estimate was made of the average number of pits per root. The abundance of the pits in different sections is shown in Table 4. As the roots were examined just as they came from the ground without washing, some pits were probably not seen and, consequently, the estimates are doubtless slightly below the actual number.

TABLE 4

Pitting in Cane Roots in Different Parishes in Louisiana, August-September, 1926

Parish	Number of fields examined	Average Number of pits per root
Ascension	24	1.9
Assumption	21	1.8
Avoyelles	7	1.3
East Baton Rouge	5	3.0
Iberia	11	1.8
Iberville	13	1.8
Lafayette	15	1.0
Lafourche	33	1.9
Pointe Coupee	10	1.1
Rapides	7	1.0
St. Charles	6	2.8
St. John	22	2.6
St. Landry	5	1.0
St. Mary	22	2.2
Terrebonne	8	2.7
West Baton Rouge	23	1.4
West Feliciana	4	1.0

An examination of the table shows that while the pitting of the roots of cane in 1926 was slightly greater in the Gulf and River Parishes, it occurred abundantly in all parts of the sugar belt of Louisiana.

Data were also obtained on the amount of root pitting on the different varieties. Certain varieties like the P. O. J. 234 are known to be resistant or tolerant to the root rot complex and it seemed desirable to determine whether these showed less of the root pitting. The data obtained in the survey as to the root pitting on some of the more important and common varieties are given in Table 5. In order to have the data more reliable, only the Gulf and River Parishes, including Ascension, Assumption, Iberia, Iberville, Lafourche, St. Charles, St. John, St. Mary and Terrebonne, are included.

TABLE 5

Pitting in Cane Roots of Different Varieties in Louisiana, August-September, 1926

Variety	Plant or stubble	Number of fields examined	Average number of pits per root
Purple	Plant	13	2.1
Purple	Stubble	24	2.0
D 74	Plant	36	3.1
D 74	Stubble	44	2.4
P. O. J. 234 ...	Plant	26	1.8
P. O. J. 234 ...	Stubble	6	2.0

The data show that the roots of all of the varieties were attacked by the root pitting animals and that the differences were not marked.

While the survey gave desirable information on the relative amount of pitting in roots in different sections of the state and on different varieties, to obtain the actual amount of pitting it was next necessary to determine accurately the ordinary number of roots on cane plants and the total number of pits that might be present.

To obtain this information, in the fall of 1926 seventeen stools of cane from the field at Baton Rouge were carefully dug up and the dirt washed away from the roots over a screen. By this method, it was possible to collect the snails, which were thought to be responsible for the pitting, that might be present in the soil around the roots. Every root was then examined and the actual number of pits obtained. The results obtained are given in Table 6.

TABLE 6

Relation of Snails and Pits

Stool Number	Number of Snails	Number of Roots	Number of Pits	Average per Root
1	11	151	907	6.0
2	8	155	522	3.3
3	11	122	454	3.7
4	4	175	607	3.4
5	12	174	430	2.5
6	9	204	532	2.6
7	0	141	409	3.0
8	11	173	329	1.6
9	0	124	213	1.1
10	1	114	555	4.9
11	4	138	460	3.3
12	8	153	553	2.6
13	4	106	315	3.0
14	0	85	224	2.6
15	3	130	244	1.8
16	2	174	559	3.2
17	3	113	425	3.7
Average	..	143	455	3.2

An examination of the table shows that an average of 3.2 pits to each cane root were found. It is probable that this fairly well represents the average conditions at Baton Rouge. While the figures obtained are somewhat greater than were obtained in the field survey during the summer, this was evidently due to the method of making counts. After carefully washing the roots, there was less chance at the time of the examination of missing the pits.

The number of snails found around the roots varied from none to twelve. At the time of examination not all of the snails found were living. Upon examination later in the laboratory, it was found that less than fifty per cent were living. The number of snails found did not seem to have any relation to the actual amount of pitting.

That the animals which pit the roots are common in the soils of South Louisiana whether under cultivation or not, is further indicated by the fact that roots of planted cane became badly pitted during the winter of 1926-27 at Baton Rouge on soil that had been out of cultivation for many years.

THE NATURE OF THE INJURY CAUSED BY THE PITS

Having obtained the information that pitting of the roots of cane is very common in all sections of the sugar belt and on all the common varieties, the next question that naturally arose was, How much and in what ways do the pits prevent the roots from functioning in a normal manner? The roots have two primary functions, to absorb the water and the mineral salts that are necessary for the normal growth of the plants and to transport these substances to the tissues of the stem or stalk. If either of these functions is interfered with to any serious extent, the growth of the plants will be checked.

There are several possible ways that the roots might be injured by the pits.

1. The pits might mechanically injure or reduce the amount of the absorbing tissues of the root and thus prevent the root from obtaining sufficient water and mineral salts from the soil to meet the demands of the plants.
2. The pits might mechanically injure the fibrovascular system, that portion of the root that transports the water and mineral salts to the other parts of the plant and thus prevent the plant from having sufficient for its needs.
3. The pits might make it easier for the entrance of the fungi and other organisms which rot the roots. This was the suggestion made by Rands.
4. The soil animals responsible for the pitting might also eat off the growing tips of the roots and thus prevent the roots from growing as they should. This might result in a root system too poorly developed to meet the demands of the plant.

To determine the nature of the injury produced by the pits, a large number of roots have been examined. Free-hand cross sections, thin enough to be examined under the microscope, have been made through hundreds of these pits. These have given information as to the depth of the pits, the kinds of tissue which are affected and the amount of rot present.

In order to discuss the injury produced in the roots, it is first necessary to give briefly the structure and the development of a healthy root.

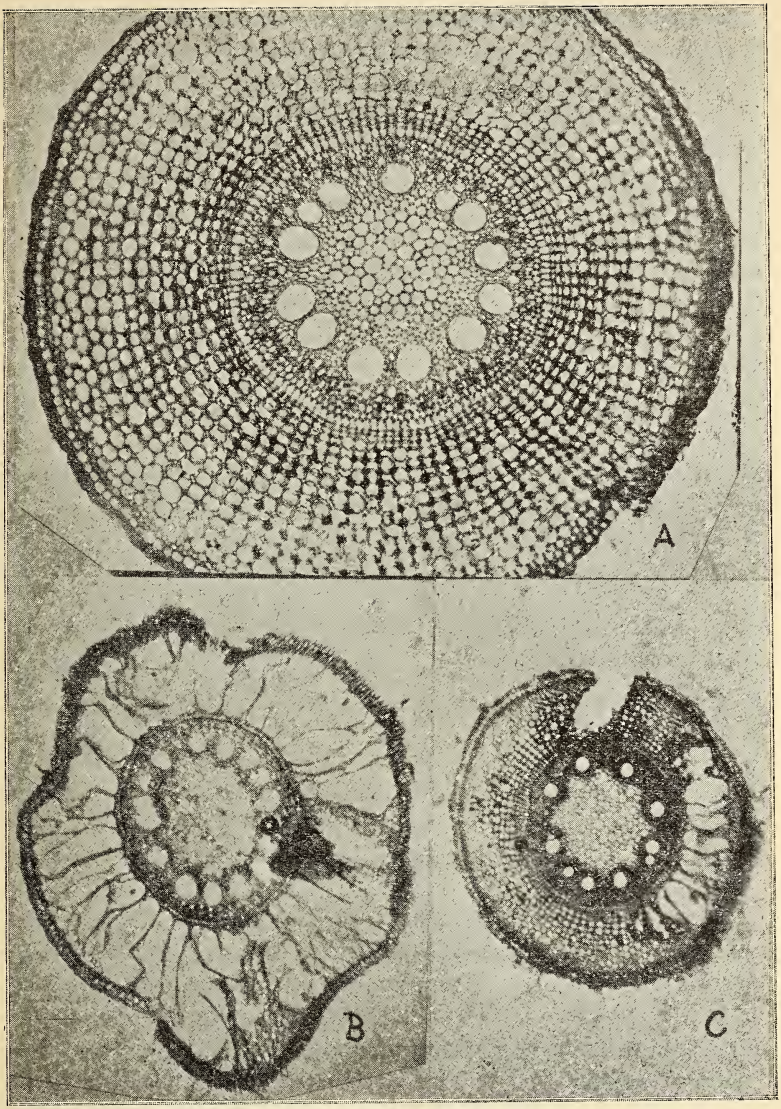

Figure 2. Cross sections of cane roots. A. Healthy root near the tip, showing the cortex and stele. B. Older stage of healthy root, showing the disintegration of the cortex tissue. C. Stage showing the disintegration of the cortex. A small pit also shows at the top.

A root when first formed is nearly white in color and is covered with many small root hairs. As the root extends further out in the soil, the older portion near the stalk takes on a dark color and the root hairs disappear. Absorption of water and mineral salts takes place to a very large extent in the white portion near the tip. A cross section of the white portion, as illustrated by the photomicrograph (Fig. 2A), shows that there are two main parts of the root, the stele and the cortex. The stele, located in the center of the root, is more or less circular and contains a number of large openings which are the open ducts through which the soil solution absorbed by the roots is carried back to the stalk. The cortex is the wide area surrounding the stele. The root hairs, show in Figure 3B, extend out from the outer layer of cells, the epidermis. The soil solution is taken up by the root hairs and is then carried through the cortex cells to the ducts in the central stele.

Now, if a section is made through the older, dark colored portion of the root it will be seen that the cortex cells are dead and are left in the form of shreds connecting the epidermis to the stele. The cortex is merely a spongy dead layer surrounding the stele which is the only living functioning portion of the root at this point. It seems that as soon as the young portion of the root grows out, the old portion ceases to function as an absorbing organ and the cortex cells, being of no further use, die. In Figure 2C is shown an early stage in the breaking down of the cortex cells, while in Figure 2B the disintegration is complete.

Now, for the pits to inhibit the absorption of water they must destroy the cortex cells very close to the tips, and to stop the function of transportation they must penetrate into and destroy the stele in the center. As the cortex only functions for a short period, it is readily seen that injuries to the cortex are relatively less important than injuries to the central stele.

The actual condition of the pitting injury as shown by the examination of 316 pits is given in Table 7.

TABLE 7

Extent of Injury Produced by Pits

Number of pits sectioned	316
Number extending to central stele only	235
Number not extending to central stele	60
Number penetrating the central stele	15
Number of pits showing cortex rot	18

As is shown by the table, a very large percentage of the pits extend only to the central stele of the root and do not penetrate into the tissue which transports the soil solution to the upper part of the plant. The tissues of the stele are harder than those of the cortex, and are not preferred by the soil animal making the pits.

Typical pits are shown in Figure 3 A-D. In Figure 4 is shown a pit which penetrates the stele slightly. In most

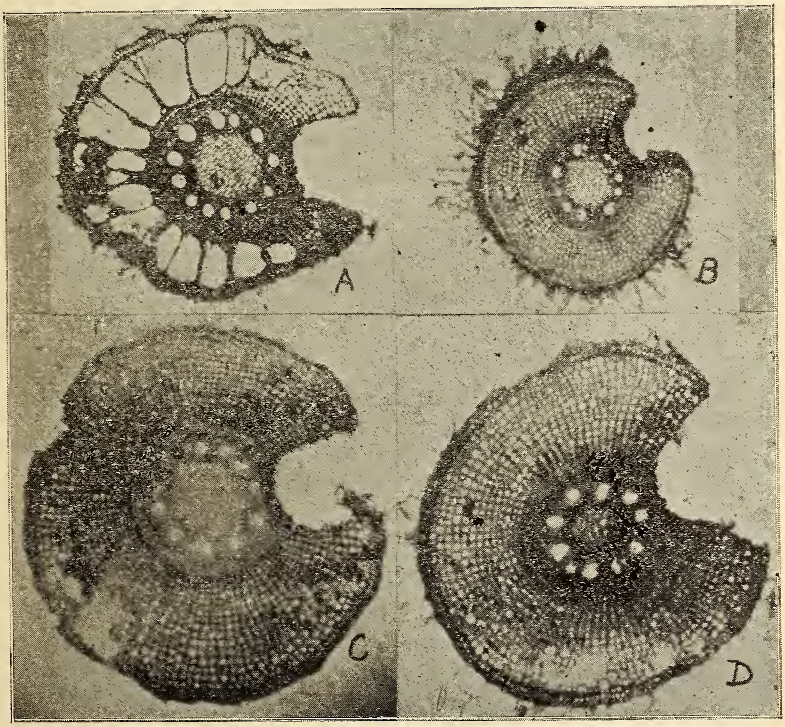

Figure 3. Pits in cane roots caused by soil animals. A. Old pit. The cortex tissue with the exception of that surrounding the pit has disintegrated. B. C. D. Typical pits extending only to the central stele.

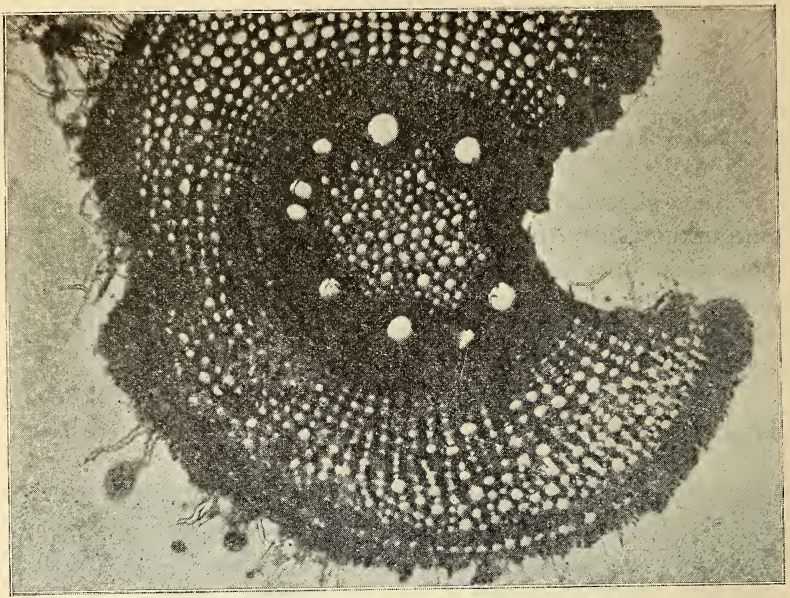

Figure 4. Cross section of root showing one large and one small pit. Rhizoctonia, mycelium shows on the edge of each pit.

cases, the cells bordering on the pit die, turn brown in color and eventually become somewhat corky in nature. This brown zone is shown in most of the figures.

As the injury caused by the pit normally affects only a few rows of cells immediately next to it, the other cells in the cortex go through their development and disintegration in a normal manner. This is well illustrated by Figure 3 A. This root was punctured while it was in the young condition. The cells surrounding the pit kept their original shape as the root became older but the rest of the cells in the cortex disintegrated in the normal manner.

The association of the pits with root rotting fungi is also a question of considerable interest. There are two types of rots occurring in the roots of sugar cane plants, cortex rots and stele rots. The cortex rots merely disintegrate the tissues of the cortex and do not penetrate into the stele, while the stele rots also affect the stele or transportation system of the root. A root affected with a cortex rot continues to function normally in transporting the soil solution, while a root with the stele disintegrated is useless. Cortex rots in the young tissues of the root doubtless inhibit the absorption of water and mineral salts to some extent but they are of little importance in the older roots. This statement is in agreement with the results which have been obtained on root rots at the Hawaiian Experiment Station.[7]

Of the 316 pits in roots which were sectioned at Baton Rouge in the fall of 1926, eighteen showed well-developed cortex rots. This is doubtless a smaller percentage than actually exists in the field due to the fact that pits followed by rots often lose their identity. In only a few cases were stele rots present in the roots sectioned and these did not seem to have any definite connection with the pits.

It should also be mentioned that cortex rots also occur abundantly in roots in which pits are not present.

DIFFERENT PLANTS SHOWING ROOT PITTING

In order to determine whether the animals that pit the roots are parasites of only a few plants like sugar cane or whether they feed on the roots of almost any plant that might be in the soil, a number of different plants growing in or near the cane fields at Baton Rouge were dug up and examined for the pits. Pits were found to be numerous on the roots of cane, corn, wild coffee weed (*Sesban macrocarpa*), Dallas Grass (*Paspalum dilatatum*) and a number of other large grasses and on the underground rootstocks of Johnson Grass (*Holcus halepense*); they were fairly common on sorghum, careless weed (*Amaranthus spinosus*) and alfalfa; a few were found on coco grass (*Cyperus rotundus*), tea weed (*Sida sp.*), Bermuda grass (*Capriola dactylon*) and cow pea; while no pits were found on soy beans, velvet beans, Sudan grass, broom sage (*Andropogon glomeratus*), crab grass (*Syntherisma sanguinale*) and cockle bur (*Xanthium sp.*). On account of the small number of examinations, the failure to find pits does not necessarily mean that they do not occur. It is evident that the roots of a considerable number of plants are attacked by the root pitting animals. Pits were also found on the roots of some of these plants on the bluff soil at Baton Rouge as well as on the alluvial soil.

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[7] Lee, H. Atherton, Well, D. M., and Barnum, C. C., "Fungous root rots in relation to Lahaina Growth Failure." Report of the Fifth Annual Meeting of the Association of Hawaiian Sugar Technologists. pp. 25-31. 1926.

TIME OF YEAR PITS ARE MADE

As to the time of year that the pits are made on the roots, it was found that fresh pits were numerous through the summer and fall and the early part of the winter up until the last part of December. During the rather cold weather during the last part of December, 1926, and the first part of January, 1927, new pits were not easily found. During the abnormally warm period following, including the last week in January and the first week in February, pitting again developed. It would seem then that the pitting occurs at almost any season except during the colder weather in the winter.

In November and December, pitting also occurred very abundantly on the roots of the freshly planted cane.

PITS ON THE ROOT TIPS

It has not been possible as yet to determine how much the soil animals cut off the tips of the young roots. It is known that under certain conditions many root tips rot or are eaten off, but it is usually not possible, by an examination, to determine the original causes of the injuries. Severed roots and pits in the extreme tips of the roots, however have been observed. This point will be considered further during the coming season.

IV. THE ACTIVITIES OF NEMATODES

Another phase of the root rot problem which is just being undertaken is the relation of nematodes. Nematodes are very small worms which enter the roots of plants producing lesions or knots. The knot condition was found in at least three parishes during the survey work in the summer, Pointe Coupee, East Baton Rouge and Lafourche, but doubtless occurs in others also. Lesions in which nematodes occur have been rather common in cane roots at Baton Rouge during the winter of 1926 and 1927. It is not possible as yet to state what bearing these organisms have on the root rot problem.

V. THE RELATION OF PARASITIC FUNGI

As fungi are always concerned in the actual rotting of the cane roots, the importance of these organisms in the root rot problem has been recognized for a long period. The early workers considered that the disease was caused by *Marasmius sacchari,* a tropical fungus similar to the one which, in Louisiana, develops the white mycelium between the lower leaf sheaths. As inoculation experiments were not consistently successful, this fungus gradually lost its importance and a search was made for others that might be more parasitic. Several other forms including species of Rhizoctonia and Pythium have been found and mentioned as possible factors in the root rot problem. The opinion prevailing in most sugar countries at present is that most of the fungi that are found on decaying cane roots are saprophytes or at the most only weak parasites and that they are capable of attacking the roots only when the latter have been weakened by adverse soil, weather or disease conditions. If this opinion is correct, it then becomes necessary to determine not only what fungi are attacking the roots but also under what conditions they are able to do so.

In beginning the intensive study on the root rot problem in Louisiana it seemed essential to first find out what fungi are on cane roots and their relative abundance. Although roots had previously been cultured in large numbers, the work had not been carried on systematically.

While making the survey in the sugar belt in August and September, 1926, roots were collected from a great many fields in various parts of the state and sent back to the laboratory for examination and culture work. Cultures were made by clipping off short pieces from diseased areas, sterilizing them lightly in an alcohol-corrosive sublimate solution and then placing them in culture media in petri dishes. After a few days, the fungi growing from the cane roots could usually be identified. The number of cultures made and the fungi which developed on them are given in Table 8. As two or more fungi often grew from a single piece of cane root, the number of organisms found does not agree with the actual number of cultures.

TABLE 8

Fungi Isolated from Cane Roots from Various Parts of Sugar Belt, August-September, 1926

Variety	Purple	D 74	Striped	P. O. J. 234	Total
Number of fields from which roots obtained	36	68	5	16	125
Number of Cultures	1080	2040	150	480	3750
Fungi present Pythium sp. ..	2	39	2	4	47
Rhizoctonia sp.	73	127	6	18	224
Marasmius plicatus	3	11	1	2	17
Trichoderma sp.	329	554	47	147	1077
Oedocephalum sp.	83	116	5	28	232
Cephalosporium sp.	69	127	7	28	231
Aspergillus sp.	56	48	1	23	128
Fusarium sp	42	101	3	31	177
Penicillium sp.	21	70	4	18	113
Rhizopus sp.	76	227	14	35	352
Acrothecium sp.	74	186	12	33	305
Alternaria sp.	1	9	...	1	11
Phoma sp.	3	1	1	3	8
Mucor sp.	14	20	1	5	40
Sclerotium (black)	34	20	7	10	71
Sclerotium (pink)	1	1	...	...	2
Other fungi	22	54	1	10	87
Free of fungi	367	601	69	163	1200
Total	1270	2312	181	559	4322

An examination of the table shows that many different fungi were isolated from cane roots and some of them in great numbers. As some of these fungi, particularly Trichoderma, would grow very rapidly and would crowd out slower growing forms or less vigorous ones, it is evident that the table does not really give the relative abundance of the different forms. The table, however, does show what fungi are normally present on cane roots.

While a great many different fungi were found on roots, some of them like Aspergillus, Penicillium, Rhizopus and Acrothecium, hardly need to be considered in the root rot problem. These are usually considered as strict saprophytes growing only on dead material. Another group, including Trichoderma, Fusarium and the Sclerotial fungi, may have slight parasitic tendencies under certain conditions. While they cannot be entirely excluded from the root rot problem, they are also probably not important. A third group, including Marasmius, Rhizoctonia and Pythium, are either known to have decided parasitic tendencies or have been suspected of such and are the ones which are of most interest in the root rot problem.

While the fungus, *Marasmius plicatus,* was not found abundantly in the root cultures, it is very common on root rot infected plants, generally on and between the leaf sheaths near the surface of the ground. The importance of this fungus is not clear at present. The early investigators of the root rot problem thought that this disease was caused by species of Marasmius but most of the later ones have abandoned that idea. Some believe that the Marasmius is not even concerned in the disease while others believe that the fungus can become parasitic if the growth of the sugar cane plants is severely checked by adverse conditions. The latter belief is probably correct.

Species of Rhizoctonia have been found to be abundant on cane roots in all parts of the sugar belt. These fungi are parasitic on the roots and stems of a great many different plants, causing the "damping off" disease of seedlings, the root rot of such plants as sugar beets and the "sore shin" of cotton. In Porto Rico and Barbados, Matz[8] and Bourne[9] have considered these fungi as very important in the sugar cane root rot problem.

Recent investigations in Louisiana have shown that the Rhizoctonias will rot the roots rapidly if kept in a highly humid culture chamber but in soil their action is not so rapid. In soil, the roots may become discolored, show numerous lesions and sometimes become misshapen.

The mycelium of the Rhizoctonias can usually be recognized in sections of diseased roots. It is on the sur-

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[8] Matz, Julius. "The Rhizoctonias of Porto Rico." Journal of the Department of Agriculture of Porto Rico. Vol. 5, No. 1. 1921.

[9] Bourne, B. A. "Researches on the root disease of sugar cane." Department of Agriculture, Barbados. 1922.

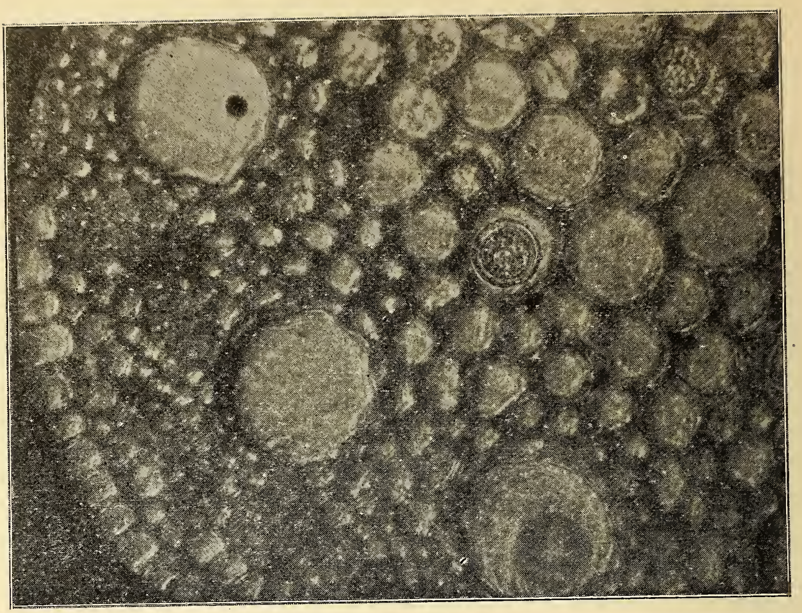

Figure 5. Cross section of cane root showing the oospores of Pythium within the stele portion.

face or close to the surface causing cortex rots but does not enter the stele. Whether it also attacks the growing tip has not as yet been determined. The two pits shown in Figure 4, contained an abundance of Rhizoctonia mycelium.

Field inoculation experiments in Louisiana with Rhizoctonia have not resulted in a consistent reduction in yield but these, of course, having been made in soils already heavily inoculated have not been conclusive. Further investigations are necessary to establish the exact importance of the Rhizoctonias.

A species of Pythium was found consistently in the cane roots in the different parts of the sugar belt though possibly it was more abundant in the southern part than in the northern. The group of fungi, of which this is a member, contains many parasitic forms. The importance of the Pythium fungi as sugar cane parasites has been recognized by Carpenter[10] and others in Hawaii. They are

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[10] Carpenter, C. W. "Morphological Studies of the Pythium-like fungi associated with root rot in Hawaii." Bulletin of the Experiment Station of the Hawaiian Sugar Planters' Association. 3:39-65. 1921.

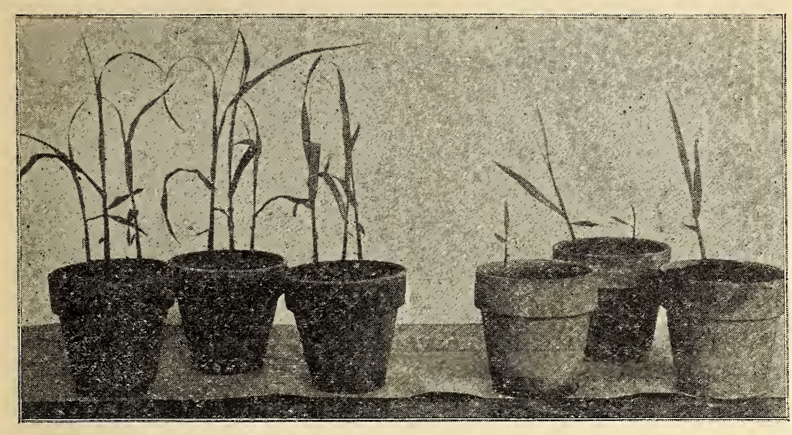

Figure 6. Root rot produced by Pythium. Soil sterilized and planted with disinfected seed pieces. Pots on the right inoculated with Pythium. Photograph taken thirty days after planting the seed.

thought to be at least partly responsible for the so-called Lahaina disease which is a form of root rot or growth failure.

The Pythium is the only fungus found in Louisiana which consistently enters the stele portion of the root. The fungus rots the whole root and the portion affected becomes soft and flabby. This agrees with the conditions found by the investigators in the Hawaiian Islands.

The Pythium fungus is easily recognized in cross sections of the root by the large mycelium and, under winter conditions at least, by the abundant development of oospores. In Figure 5, the spherical oospores can be seen in the ducts and cells of the stele.

In January and February, 1927, many roots developing from the planted seed pieces of many varieties at Baton Rouge were found affected with Pythium.

Inoculations in the greenhouse with Pythium have shown that the fungus is very parasitic, at least under certain conditions. In Figures 6 and 7 are shown seed pieces taken from inoculated soil as compared to others taken from uninoculated soil. The soil was previously sterilized with steam and the seed pieces were soaked with a disinfectant before planting in order to remove any other organ-

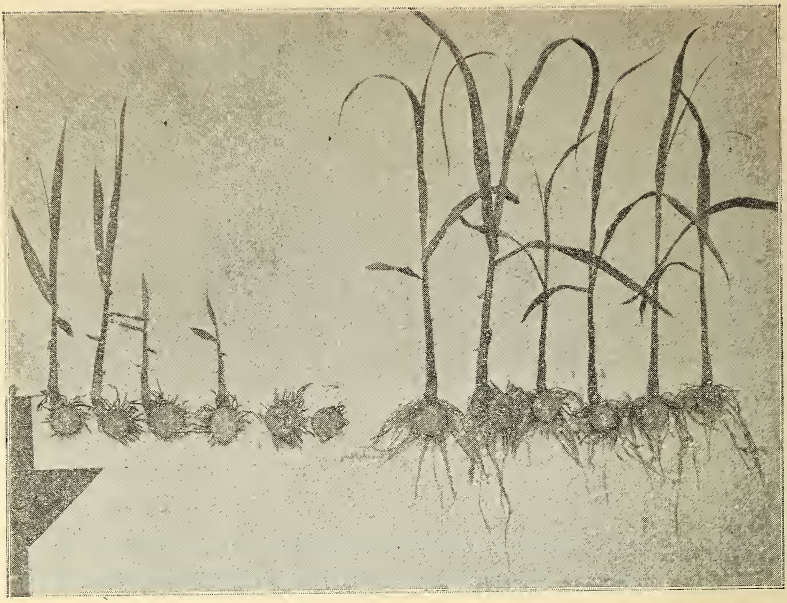

Figure 7. Root rot produced by Pythium. Same plants as shown in Fig. 6. Plants on the left inoculated with Pythium.

ism or parasite. These seed pieces had been in the soil for 31 days, from January 17 to February 17. The roots on the seed pieces in the inoculated soil were badly rotted while those in the uninoculated soil were perfectly healthy. The germination and growth of the buds was also prevented or retarded.

While no data are at present available on the development of this fungus under the temperature and soil conditions existing in the field during the spring and summer seasons, our knowledge of the abundance of the fungus and its parasitic tendencies at least under some conditions make it seem probable that it is one of the factors in the root rot problem. Before the importance of the fungus can be definitely known, the soil and temperature conditions under which it is most active must be determined.

Pokkah Bong Disease

A disease identical with or similiar to the one known in Java as Pokkah bong, a Japanese term meaning twisted top, has in recent years made its appearance in Louisiana. The

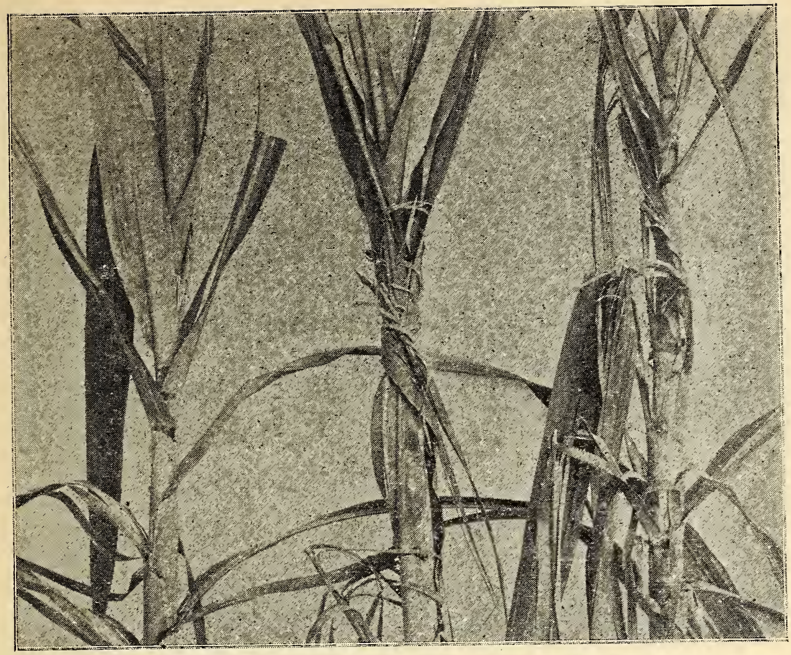

Figure 8. Pokkah Bong disease. Old stage showing the twisting of the leaves. Plant on the left healthy.

identity of the Louisiana disease with the one in Java was confirmed by H. Atherton Lee of the Hawaiian Sugar Planters Experiment Station while making a trip through Louisiana in the summer of 1926. While the disease was very common during the summers of 1925 and 1926, as far as is known, this is the first published report on it.

Pokkah bong first shows in the new leaves as they come out of the terminal bud. The leaves are light colored and are much twisted, frequently to such an extent that they are practically tied together. Sometimes these young leaves rot and, on this account, the disease has frequently been called top rot in Louisiana. Uusually, however, the leaves grow partially out of this twisted condition. New leaves that develop later may show little signs of the disease. The internodes which form in association with the twisted leaves very frequently remain short (Figs. 8 and 9).

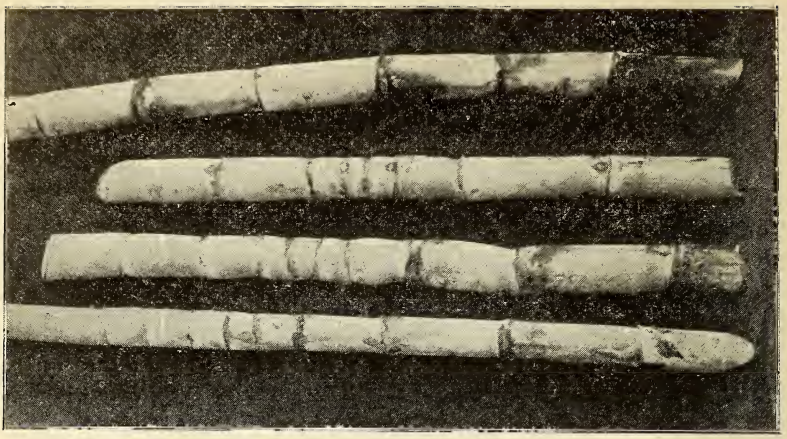

Figure 9. Pokkah Bong disease. Old stage showing the short internodes. One stalk healthy.

This disease was first observed on the newly introduced Java seedlings but later appeared on the Purple, D 74 and other Louisiana varieties.

Practically nothing is known concerning the cause of the disease.

While this disease might be considered of minor importance by itself, it is one more thing added to an already much diseased crop. The sugar industry at the present time is afflicted with too many of the so-called minor troubles.

INVESTIGATION ON CONTROL MEASURES

The prosperity of the sugar industry of Louisiana depends to a very large extent upon the efficiency of the control measures for the three major diseases, the mosaic, the root rot complex and the red rot. If these diseases and the cane borer were not present, the sugar belt of Louisiana on account of its favorable soil and climatic conditions should produce on an average of 30 to 35 tons of cane per acre. During the past sixteen years, with these diseases present, the average yield has been 14.05 tons. In order for the sugar industry to emerge from the present economic conditions, an average yield of at least 20 tons will probably be necessary.

Successful control measures for any disease depend upon the possibility of finding some line of attack whereby the host plant may be able to throw off or counteract the parasite or which will prevent the parasite from attacking the host. The formulation of control measures is usually not possible until after the disease has been thoroughly studied. For the cane diseases, the experiences and observations of many workers in many countries have indicated what must probably be the nature of the control measures. Successful control, however, will depend largely on the efficiency and practicability of these measures. The control measures which have been formulated for the mosaic and root rot can be stated briefly.

For the mosaic disease, the control measures depend upon the severity of the disease in a region. If it is not present, or occurs in a small amount, its introduction and spread should be prevented by quarantine, use of disease free seed and roguing. If the disease is wide-spread, it should be controlled by the use of immune or tolerant strains or varieties.

The recommended control measures for the root rot include the use of tolerant varieties and the adoption of better cultivation practices such as a satisfactory rotation, better drainage, more efficient cultivation and fertilization or any other practice that will better the growing conditions of the plant or will retard the development of the parasitic organisms living in the soil.

In Louisiana, the investigations on control measures have been along the several lines that seem to offer the most promise including, (1) seed selection, (2) use of resistant varieties, (3) seed treatment, (4) soil treatment and (5) cultivation practices. Some of these investigations have been continued long enough to obtain definite results while some of the others must be continued for some time.

Seed Selection

For a number of years, seed selection experiments have been conducted at the Experiment Station. The work was started to determine whether it was possible to select strains of the old varieties that were immune or tolerant to the mosaic disease. Later the work was broadened to include the root disease. The work as it is now in progress, is to determine the possibility of selecting seed cane tolerant to the mosaic and also comparatively free or tolerant to the root disease.

In selecting cane for seed purposes, stools are chosen that show the following characteristics: (1) they must contain a standard number of stalks of more or less equal size; (2) all of the stalks must show a vigorous growth and be apparently free of root disease; (3) the leaves of the plants must show the mosaic mottling in the least pronounced form.

After several years of continuous work, strains have been obtained which show the mosaic in a very mild form. These strains also have invariably given greater yields.

With the exception of the records for 1926, the results on seed selection have been published in bulletin form.[11] To bring the results to date, the yields obtained with the plant cane during the several years at the Sugar Experiment Station at New Orleans and Baton Rouge are given in Table 9.

TABLE 9

Results of Seed Selection, Plant Cane

Purple Cane			D. 74		
Year	Selected	Unselected	Year	Selected	Unselected
1922	19.89 tons	17.37 tons	1922	14.90 tons	10.58 tons
1923	19.7	18.5	1923	11.9	8.85
1925	28.10	20.88	1925	21.97	14.90
1926	27.47	19.13	1926*	17.27	15.83

*The stand of the D 74 cane in 1926 was not much better than 50%.

Results on the effect of selection on the stubble crop are available for only one year on one variety. In 1926, the stubble from the selected plot of Purple cane produced 24.5 tons per acre while an adjoining plot selected for the presence of mosaic and root rot produced 13.98 tons.

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[11] Edgerton, C. W., Taggart, W. G., and Tims, E. C. Selection of seed cane. Louisiana Experiment Station Bulletin 195. 1926.

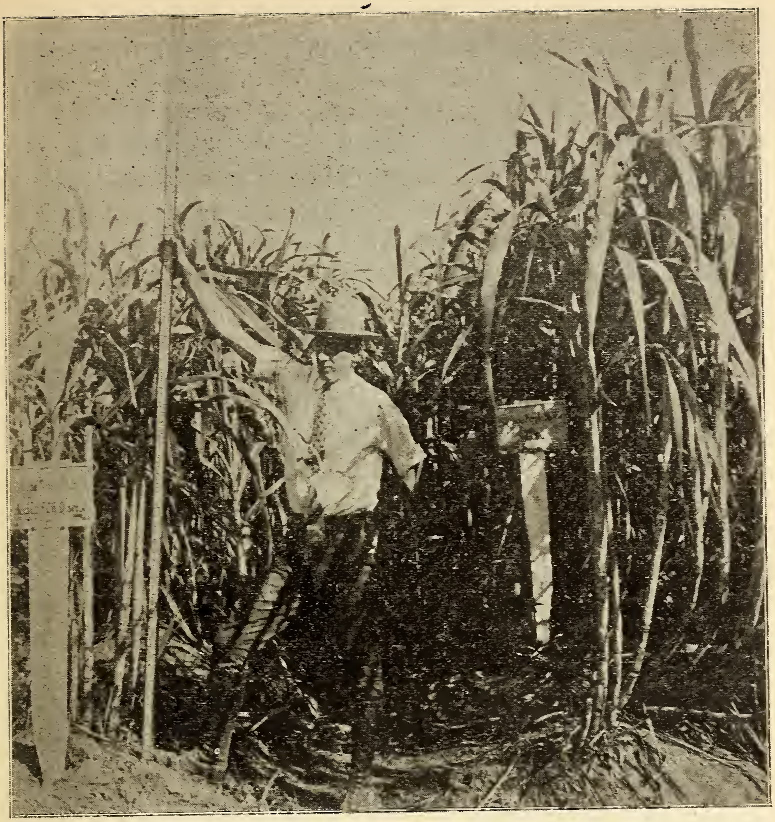

Figure 10. Stubble Purple cane showing results from seed selection. Row on the right selected for tolerance to mosaic and root rot. Row on left selected for susceptibility to two diseases.

The selection work has been very gratifying in at least two respects. *First,* the selected plots have always given an appreciably larger yield than the unselected. *Second,* strains of Purple cane and D 74 have been obtained which show the mosaic in an extremely mild form. Although all of the cane is known to have the disease, at certain seasons of the year it is practically impossible to see clear cut mosaic symptoms on most of the leaves.

The results obtained in the seed selection work are more or less contrary to the general opinion in regard to mosaic. In almost all the published articles on the disease, statements to the effect that affected cane deteriorates from year to year can be found.

The cane used in the Louisiana selection experiments has been infected with the mosaic disease as long as any cane in the State, having come from the district that was presumably first infected. It is known to have had the disease for a period of ten to fifteen years at least. According to the general opinion in regard to mosaic, this cane should show serious signs of deterioration, yet the Purple variety produced 27 to 28 tons as plant cane in both 1925 and 1926 and as stubble in 1926 produced more than 24 tons. It is evident that the mosaic is causing no appreciable loss to this selected cane.

If seed selection gives good results with two varieties, it is reasonable to expect that it will be beneficial with other varieties. No matter what variety is eventually adopted as the standard one in Louisiana, yields with it can probably be improved by careful seed selection.

An attempt was made to determine the percentage of the cane in the state that would meet the standards set for the selection work. In the survey made in the summer, counts were made in all of the fields to determine the percentage of plants showing the mosaic in a very mild form. The disease has entirely covered the sugar belt of the state though in a few fields in the northern and western part of the area, the infection was not 100 per cent. In the whole survey, the lowest percentage of mosaic found was 40%. Taken as a whole, however, there were very few fields that were not completely infected. To bring out the condition of the fields in the cane belt, the fields were grouped in relation to the percentage of mild mosaic. In Table 10 is shown the number of fields of the common varieties in the different percentage groups.

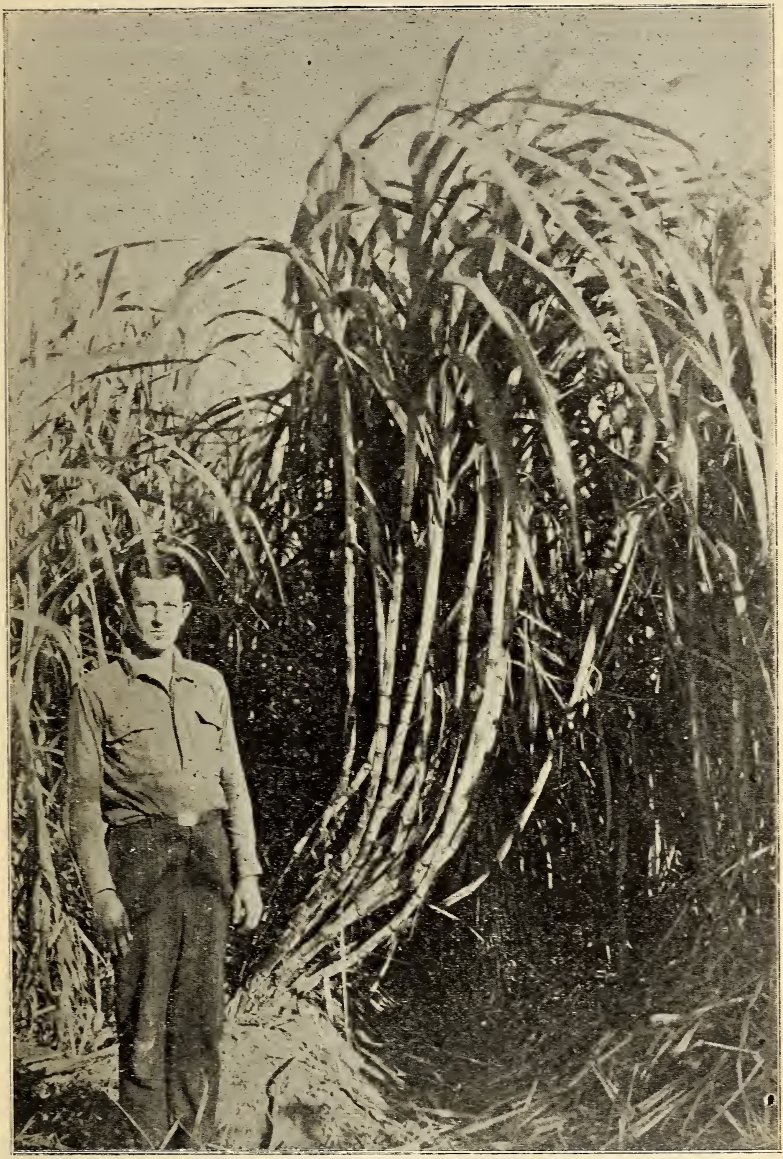

Figure 11. Plant Purple cane, selected for resistance to mosaic and root rot. Yield in 1926, 27.47 tons per acre.

TABLE 10

Number of Fields with the Different Percentages of Mild Mosaic

Mild mosaic percentage	Purple Plant	Purple Stubble	D. 74 plant	D. 74 stubble	P. O. J. 234 plant
0%	0	2	3	7	1
1-2%	3	2	7	14	4
3-5%	6	12	11	11	8
6-10%	10	17	8	7	9
11-15%	4	5	7	4	10
16-20%	3	3	7	7	3
21-25%	1	2	2	3	0
26-30%	1	1	0	0	0

The data obtained from the survey showed that from five to ten percent of the plants of the common varieties had the mosaic symptoms in only a mild form. While a few fields, as is shown in the table, had but few such plants, the most usual condition was from five to ten percent. This information is of interest as it shows that there is cane in most all sections of the state suitable to be selected for seed and it also shows the approximate percentage of stools that one could ordinarily expect to obtain from a field.

Use of Resistant Varieties

Cane varieties vary in regard to their resistance to diseases. Some varieties are practically immune to some diseases. Others are more or less tolerant while some are very susceptible. The use of resistant varieties has been and still is the standard method of controlling cane diseases in practically every sugar producing country. Just because a variety is resistant to a disease, however, does not necessarily mean that it is a desirable cane in any country. In selecting a cane for any district, all of the characteristics, one of which is resistance to disease, must be carefully studied.

Extended variety tests have been carried on at the Experiment Station for many years. In fact, this has been one of the major projects in the sugar work. During the past few years, these trials have included most of the seedlings from Java and other places that have shown a resistance or tolerance to certain of the diseases. The results of this work are being published in a separate bulletin. Some of these varieties are tolerant to mosaic and root rot and offer considerable hope. Few of the varieties, however, are immune to these diseases and, consequently, maximum yields cannot be expected with them if grown under conditions favorable to the diseases.

Seed Treatment

The possibility of controlling some of the cane diseases by treating the seed pieces with a disinfectant has been recognized by growers and investigators in practically every sugar producing country. Attempts to control some of these troubles by seed treatment date back to almost the earliest workers in Java, Hawaii and the West Indies, and tests of one kind or another have been, and are still, being run in many places.

In general, the results which have been obtained in the various countries in the seed treatment tests have not been very satisfactory. For seed treatment to be successful, the organisms causing the diseases would have to be on the seed pieces in such a condition that they would be destroyed by the disinfectant, or else the disinfectant would have to remain on the seed pieces or in the surrounding soil and be efficient enough to prevent the development of the parasitic organisms occurring in the soil.

In Louisiana, a large number of tests with many disinfectants, including formaldehyde, copper compounds, cyanamid, organic mercury compounds like Semesan and Uspulun, and corrosive sublimate have been made. Consistent results have not been obtained in this work. While some of the tests seemed to be promising, others conducted in a similar manner gave negative results. On this account, it does not seem necessary to publish the actual results obtained. While definite statements cannot as yet be made in this regard, the chance of controlling any of the troubles in the root rot complex by seed treatment seems rather doubtful.

Soil Treatment

During the past two years, a few tests have been made to determine the possibility of checking the development of some of the root parasites by treating the soil with disinfectants and other substances. There is always the possibility that some substance may be applied cheaply enough for it to be of economic importance. Quite recently, Rands[12] ran some tests with paradichlorobenzene and he reports that better stands were obtained where it was applied as it temporarily checked the activities of the snails.

In the summer of 1926, there was one plot of stubble cane on the Experiment Station farm at Baton Rouge which was very severely affected with root rot. The stunted cane was yellow and the roots were covered with the pits made by soil animals. To determine if soil treatment might check the root parasites and permit the cane to grow, the soil around the cane stools in a portion of a row 32 feet long was treated with each of the following substances:

Formaldehyde: 1 pint to 30 gallons of water, 4 gals.
Formaldehyde: 1 pint to 15 gallons of water, 4 gals.
Copper sulphate: 1-200 solution, 4 gals.
Mercuric chloride: 1-200 solution, 4 gals.
Mercuric chloride: 1-1000 solution, 4 gals.
Paradichlorobenzene: 2 oz. per stool.
Paradichlorobenzene: ½ oz. per stool.
Carbon disulphide: 200 cc. per stool.
Pexitone: 1-100 solution, 4 gals.
Sulphur: at rate of 1,000 lbs. per acre.
Tobacco dust: at rate of 500 lbs. per acre.
Cyanamid: at rate of 100 lbs. per acre.
Cyanamid: at rate of 200 lbs. per acre.
Sodium fluorosilicate: at rate of 225 lbs. per acre.
Sodium nitrate: at rate of 250 lbs. per acre.
Sodium nitrate: at rate of 1250 lbs. per acre.
Kainit: at rate of 200 lbs. per acre.
Semesan 0.5% solution; 4 gals.

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[12] Rands, R. D. Root disease of sugar cane in Louisiana. U. S. Dept. of Agriculture, Department Circular 366. 1926.

Pythal: 15 cc. to 2 gals. of water, 4 gals.
Kalimat: 40 cc. to 2 gals. of water, 4 gals.
Betanal: 0.75% solution, 4 gals.

The soil was removed from around each stool for a distance of one foot, the substance was applied as evenly as possible and the soil returned. Some of the substances like carbon bisulphide, paradichlorobenzene, and sodium fluorosilicate are known to be very poisonous to insect and other animal life.

The canes treated with carbon bisulphide and pexitol were burned very badly by the treatment and most of them died within a few days. The other treatments did not seem to injure the canes.

These canes were watched through the rest of the season and measurements were made on the growth. Examinations were also made of the roots. As far as could be determined, the subsequent growth of these canes was no different from that of untreated canes. All of the cane in the plot improved as the season advanced, but the improvement was no greater in the treated than in the untreated areas.

TESTS WITH PARADICHLOROBENZENE (PDB)

Paradichlorobenzene has also been used on planted seed pieces in the fall and on the young growing cane in the spring.

As this substance is known to be toxic to plant growth, some preliminary tests were made to determine how much would be safe to use. In September, 1925, nine lots of D 74 cane, each containing 100 good eyes, were used in a planting experiment. In four of the lots, paradichlorobenzene was applied directly to the cane at the rate of 0.5, 2 and 3 oz., to the linear yard. In four other lots the cane was first covered with two inches of soil and then the same amounts added. The ninth lot was left as a check. The germination of the eyes after 69 days is given in Table 11.

TABLE 11

Germination of Cane Treated with PDB

0.5 oz. PDB applied directly to planted cane, eyes germinated	13
1 oz. PDB applied directly to planted cane	2
2 oz. PDB applied directly to planted cane	0
3 oz. PDB applied directly to planted cane	1
0.5 oz. PDB applied above two inches of soil	22
1 oz. PDB applied above two inches of soil	9
2 oz. PDB applied above two inches of soil	7
3 oz. PDB applied above two inches of soil	1
Check, no PDB applied	43

No matter how it was applied, the paradichlorobenzene seemed to hurt the germination of the seed, though the injury was less when it was applied two inches above the seed cane.

In the fall of 1925, plots were planted with Purple cane for treatment with paradichlorobenzene. In two plots, this substance was applied directly to the seed pieces at the rate of 0.5 and 2 oz., per linear yard. In two other plots, it was added in the spring, April 10, at the rate of 2 and 3 oz. per linear yard. Two plots were left as checks. The yield from this cane at grinding time in the fall of 1926 is given in Table 12.

TABLE 12

Effect of Paradichlorobenzene on Yield of Cane

Amount of PDB per linear yard of row	When applied	Yield, tons per acre
0.5 oz.	Planting time	6.2 tons
2 oz.	Planting time	5.55 tons
2 oz.	Spring	32.48 tons
3 oz.	Spring	28.60 tons
0 (First check)		23.48 tons
0 (Second check)		33.61 tons

As is seen by the table, paradichlorobenzene applied on the cane at planting time reduced the germination to such a point that the yield was very low. When it was applied in the spring to the growing cane, the yields seemed to be about the same as the checks. No beneficial effect of the substance was observed.

TEST WITH CYANAMID

As cyanamid is known to have a toxic effect on fungi and also on higher plants when used in large quantities, a planting test using large amounts was started in the fall of 1925. Cyanamid was applied at the rates of 360 and 720 lbs. per acre at the time the cane was planted. In some of the plots, the cyanamid was mixed with the soil while in others it was placed in the furrow and the cane planted directly on it. The yields obtained are given in Table 13.

TABLE 13

Effect of Large Amounts of Cyanamid, Applied at Planting Time, on Yield

360 lbs. applied directly to planted cane	Yield 16.39 tons
720 lbs. applied directly to planted cane	Yield 5.22 tons
360 lbs. mixed with the soil	Yield 18.30 tons
720 lbs. mixed with the soil	Yield 15.60 tons
Check, no treatment	Yield 22.42 tons

Large amounts of cyanamid seemed to cause a decrease in germination and consequently a decrease in yields. The amounts of the material used were much larger than would ordinarily be used on cane. Cyanamid as ordinarily used in a fertilizer experiment has not had any effect on the germination of the cane. As a fertilizer, cyanamid has given as satisfactory results as have other nitrogenous materials.

As far as the work has advanced at present, no beneficial results from a root rot standpoint have been obtained by soil treatment.

Cultural Practices

It is generally recognized in most tropical countries that measures based upon cultural practices are at present the most practical for the control of the root rot complex of troubles. In cultural practices are included drainage, irrigation, fertilization, cultivation, seed bed preparation, rotation, cover crops, etc.

Many of the root parasites of cane are weak parasites and attack the roots seriously only when the cane is not growing at its best. Any condition which checks the growth of the cane makes it more subject to attack and any condition which favors growth makes it less subject.

No definite control experiments based upon cultural practices have been planned but in all of the cane work at the Experiment Station an attempt has been made to make the growth conditions as favorable as possible for the cane and as unfavorable as possible for the root parasites. Even with the mosaic and other troubles present, yields as high as 33 tons have been made with the Purple cane, 29 with D 74 and more than 35 tons with some of the P. O. J. canes. These yields have demonstrated that excellent yields can be grown even with a maximum of the mosaic disease present if the other troubles are kept at a minimum.

The idea that some planters have that the new P. O. J. canes will make good yields in spite of drainage, rotation and cultivation conditions is a serious mistake. These canes are more resistant to diseases and other adverse conditions than the so-called native canes but they are a long ways from immune and they will respond to good treatment just the same as any other plant. Unless yields better than 12 to 16 tons per acre are obtained, the cane industry will not emerge from the crisis in which it has been during the past few years. These canes are capable of making from 30 to 35 tons and growers should not be satisfied with less.

SUMMARY

This bulletin has been written for the purpose of putting into the hands of the planters and other interested in the sugar industry the data on cane troubles which have been obtained by the Experiment Station during the past two years, rather than to present opinions and conclusions. The points brought out or discussed are briefly summarized.

1. During a period of at least four years, 1923-26, the sugar crops of Louisiana have been very unsatisfactory. The crop of 1926 was the smallest which has been produced for many years.

2. A number of factors have acted in an adverse way upon the recent sugar crops. These include weather con-

ditions, cultivation and drainage conditions, cane borer infestation and the attack of cane diseases.

3. Winters with heavy rainfall are usually followed by poor cane crops. The rainfall in January, February and March, 1926, was the heaviest on record.

4. Cultural and drainage practices have apparently made the cane more susceptible to root rot attack.

5. The major cane diseases, red rot, mosaic and root rot, have exerted a great influence on the cane crops.

6. The root rot, better considered as the root rot complex, prevents the normal functioning of the roots. The plants are usually stunted.

7. Root rot is not due to a single cause. Among the factors considered are: (a) the presence of toxic substances in the soil, (b) the improper ratio of the mineral elements in the soil, (c) the pitting of the roots by soil animals, (d) the activities of nematodes and (e) the relation of parasitic fungi. Investigations on root pitting and parasitic fungi are discussed.

8. Pits on the roots of cane, produced by soil animals, are very abundant in Louisiana. Most of the plants in the state have on an average of one to four pits to each root. Root pitting occurs in all sections of the state.

9. Most of the pits are in the cortex region of the root and only a very small per cent penetrate the central stele. Injury to the cortex is less important than to the stele. The cortex tissue naturally degenerates as it becomes older.

10. Rots of the cortex sometimes follow the root pitting injury. No relation was observed between the pits and the stele rots.

11. Various other plants, both cultivated and wild, also show root pitting.

12. Pitting evidently occurs at all seasons of the year except during the colder weather in winter.

13. Many fungi are found on cane roots. Many of these are saprophytic but a few of them, including species of Marasmius, Rhizoctonia and Pythium, are parasitic at least under some conditions.

14. A species of Pythium is the only fungus found that seems to be able to attack the stele of the roots. Roots affected with Pythium become soft and flabby.

15. Inoculation experiments with the Pythium have been very successful and it seems probable that this fungus is important in the root rot problem.

16. The Java disease, known as Pokka Bong, has been developing in the state during the past few years.

17. Investigations on control measures have included, (a) seed selection, (b) use of resistant varieties, (c) seed treatment, (d) soil treatment and (e) demonstration of cultural practices.

18. By seed selection, strains have been obtained which are very tolerant to the mosaic disease and are not seriously affected by the root rot. Excellent yields have been obtained with these strains.

18. Results from seed and soil treatment have not always been consistent.

19. The use of good cultural practices has resulted in good cane yields.

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LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE
AGRICULTURAL EXPERIMENT STATIONS

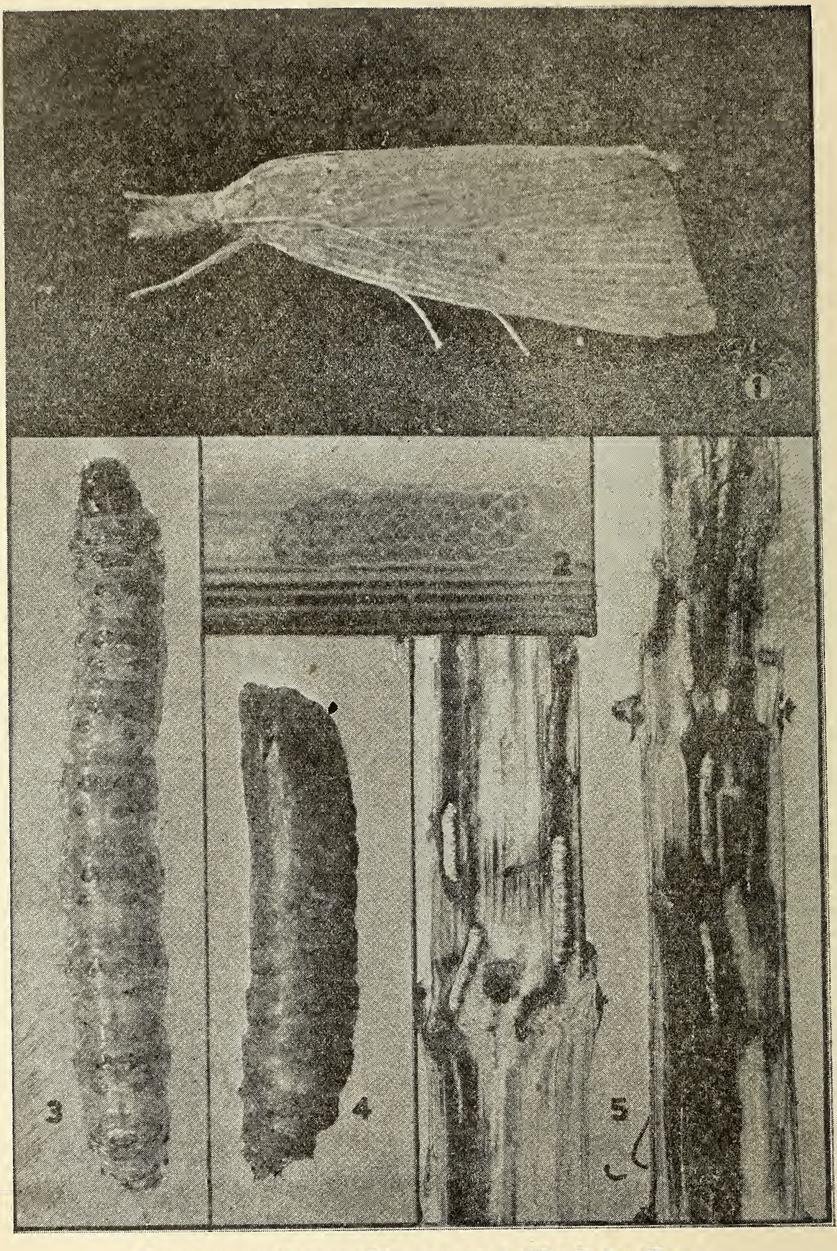
W. R. DODSON, Dean and Director

BATON ROUGE, LOUISIANA

SUGARCANE BORER CONTROL AIDED THROUGH UTILIZATION OF INFESTED AND TRAP CORN

By W. E. HINDS *and* HERBERT SPENCER

Plate I.



Sugarcane Borer Stages and Work in Cane

Fig. 1, living moth in resting position; fig. 2, large batch of eggs; fig. 3, full-grown larva; fig. 4, pupa; fig. 5, heavy infestation in cane stalks. Photos by T. H. Jones. Figs. 1-4 x 4/1.

SUGARCANE BORER CONTROL AIDED THROUGH UTILIZATION OF INFESTED AND TRAP CORN

By W. E. HINDS *and* HERBERT SPENCER

Preface

For more than thirty years the sugarcane moth borer (**Diatraea saccharalis crambidoides** Grote) has been recognized as being the worst pest of sugarcane in Louisiana. In 1900 the Louisiana Experiment Station Entomologist began a study of the life history and control of this species. The results of this study were reported in 1902.[1]

The U. S. Bureau of Entomology undertook a thorough study of this pest about 1910 and established the Sugar Cane Insect Laboratory at New Orleans in connection with the Audubon Park Sugar Experiment Station. A very valuable report of this work was published in 1919.[2]

During recent years Messrs. T. H. Jones and William G. Bradley, of the Louisiana Experiment Station, have added numerous records particularly with reference to the breeding of the cane borer in wild grasses found around Baton Rouge. We are indebted to them also for a number of the illustrations used in this bulletin.

Early recognition of the importance of borer development in corn is shown by the following quotation from Stubbs & Morgan, ([1]) page 912. "Corn is more succulent, more rapid in development, and thus in the economy of the borer assures the development of many more specimens than if cane were the only food plant of the first two broods. From the first appearance of young cane shoots up to June the 1st or 15th, but few borers can be found on individual (**cane**) plants (not more than five or six, commonly only two

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(1) Louisiana Experiment Station Cir. No. 70, 1902, By Stubbs and Morgan.
(2) U. S. D. A. Bul. No. 746, 1919, Holloway & Loftin.

or three), while upon corn at this season as many as fifty-six have been found upon a single stalk, while from fifteen to thirty to the stalk is of usual occurrence."

In spite of this plainly important information, Louisiana cane growers have continued to raise corn and cane together with no definite effort to limit the multiplication of borers in either crop. The damage sustained by cane has been estimated by Mr. Holloway and Mr. L. L. Janes, Agricultural Statistician of Louisiana, at approximately 20% of the crop in an average for a number of years. In 1925 the loss was the greatest ever sustained and amounted to ⅓ of the total crop of the State.

In the fall of 1925 the writers took up a study of the cane borer and its control as their principal investigation. The volume of work possible was greatly increased through the special appropriation for Sugarcane Investigations as made by the Louisiana Legislature in July, 1926. Mr. B. A. Osterberger and Mr. C. L. Stracener have assisted materially in the field work on the borer. This Bulletin reports particularly some of the more important observations relating to the life history, habits and the attack of the borer on corn, with special reference to the control of the pest in corn which now seems to be practicable and advisable as one important step in reducing the damage inflicted by this pest to both corn and sugarcane.

Early Breeding in Corn vs. Cane

That cane borer larvae and pupae can be found usually in corn far more readily than in cane up to the end of July is a matter of common knowledge. It has, in fact, been so evident as to lead to the suggestion that the borer attack on cane may be greatly decreased by eliminating altogether the production of corn in any locality. However, it is now evident that complete elimination of corn does not affect greatly the number of borers passing through the winter and emerging to lay their eggs in the spring. These moths will be capable of depositing the same number of eggs whether they lay them on corn or on cane. If no corn occurs in the locality, the moths will surely scatter their eggs more widely through the cane fields and thus increase the early season infestation in the cane. Our observations agree with those of Stubbs and Morgan quoted above to the effect that during the first two generations a larger proportion of the eggs laid on corn produce adult moths than is the case with the eggs laid on cane during that period. Therefore where no corn is present through a large area, the effect of the elimination of corn will be to scatter more widely the infestation in cane and to increase the initial attack but to decrease considerably the number of borers that will become adult by the end of the second generation.

On the other hand, if corn is grown, even in garden patches and small field areas, the moths emerging from over-wintered larvae will concentrate their egg laying on the more favorable corn in preference to the less favorable cane. If then nothing is done to check their development in the corn, there will be a considerable increase in attack on the late corn and also an increased attack on the cane after the corn crop has matured and the moths transfer their attention to the then more attractive cane.

Control in Corn Is Possible

Holloway states (loc. cit.) p. 53, "If the corn stalks could be destroyed before the borer moths leave them, a large number might be killed and the subsequent infestation reduced." Both the field observations, and the actual experience of a number of planters in 1926, indicate that it is entirely possible and practicable to so handle the borer-infested corn as to check decidedly the multiplication of borers therein. If this be done, it may be possible to continue the production of corn, as most cane planters insist that they must do, but to destroy a large proportion of the borers in the corn field by cutting out and feeding green, or otherwise treating or disposing of the actually infested stalks, so that the borers will be killed before the moths emerge therefrom.

The immediate problem therefore is to so utilize corn and the attraction of borers thereto as to take advantage of this concentration and thereby protect the later developing fields of cane.

Seasonal History and Life History of Cane Borer

The following brief outline will help to give a clear understanding of the principal facts underlying these cane borer control recommendations.

The sugarcane borer passes the winter in Louisiana in the larval stage only. The development of larvae through the fall and winter may be greatly retarded and extend over more than six months. The larvae grow slowly through the winter until they become full-grown. Pupation (change to the moth stage) then occurs in the spring soon after cane sprouting becomes general in the fields. These over-wintering larvae may be found principally in the cane used for planting and in the thicker parts of the top trash which is left on the surface of the ground. They may sometimes occur abundantly also in the stems and crowns of native large-stemmed grasses. Jones and Bradley, in 1922 to 1923, found them quite abundant in *Panicum barbinode*, and somewhat less common in *Panicum dichotomiflorum* and also in *Phanopyrum* (Panicum) *gymnocarpum*. Only rarely does the sugarcane borer breed in the various species of "broom sedge" (Andropogon spp.) but another species known as *Platytes densellus* Zell., which resembles the cane borer closely in appearance and work but is plainly smaller in size, does occur abundantly in the "broom sedge." The cane borer does develop in sorghum species and in the closely related "Johnson grass" (*Sorghum halepense* L.)

During February, 1927, at Baton Rouge, some pupae were found in stalks of corn and cane and the first moth emerging from these pupae came out on March 3rd. The moths coming from these over-wintering larvae are referred to as "over-wintered moths." The time of their emergence in the spring depends directly upon climatic conditions and will be early or late as the season is early or late. The stage of development in 1927 is at least four weeks ahead of that occurring in 1926 at Baton Rouge. The moths (Pl. I, fig. 1) are divided in practically equal proportions between male and female. The emergence occurs during dusk or at night and the moths are active only during this period so they are but rarely seen in the fields. The eggs (Pl. I, fig. 2) are laid in batches of from 15 to 50 usually, upon the most favorable food plants that they can find. This means that early-planted corn and the most thrifty-growing cane attract most of the oviposition during the spring and early summer. Later in the season, after corn has matured generally and the cane has increased in its growth, the cane becomes relatively much more attractive. However, very late-maturing corn may be completely riddled by the borers.

Borer Development and Generations

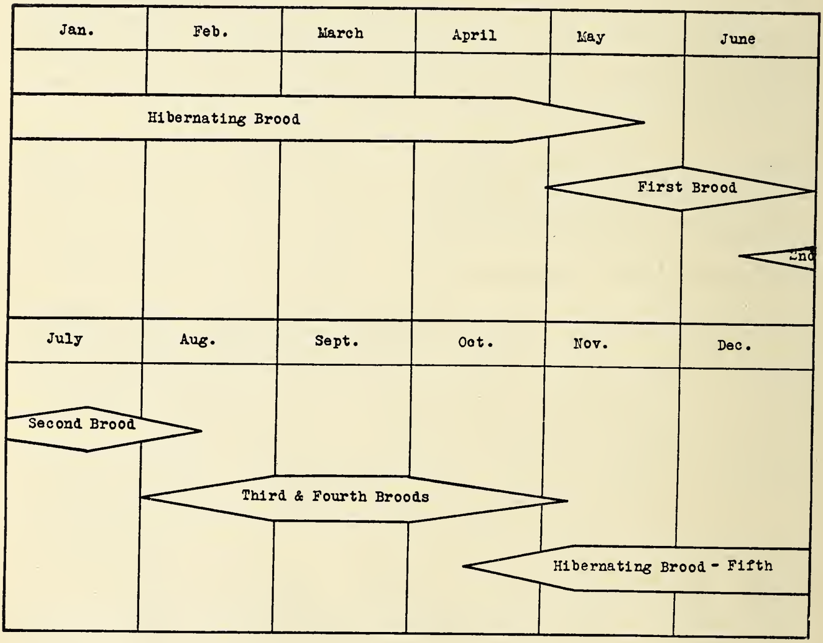
According to Mr. T. E. Holloway of the Sugarcane Insect Laboratory, who has given much attention to this matter, the periods required for the various stages in borer development are approximately as follows:

STAGE	Minimum		Maximum		Average
The egg stage requires usually	4	to	9	—	5 days
The larval stage requires usually	20	to	35	—	28 days
The pupal (brown) stage, usually	7	to	21	—	9 days
Full development requires usually	31	to	65	—	42 days

As the borer larvæ grow they shed their skins and as a rule five distinct sizes or stages of larvæ may be recognized. The first two larval stages feed usually in the leaf roll. The third stage may occur in the mid-ribs of leaves or may burrow into the tender part of the stalk, generally at about the growing point. The fourth and fifth stages occur usually farther down the stalk (Pl. I, fig. 3) and their entrance holes into the joints of corn or cane, or their emergence holes therefrom, are much larger and more easily recognized. One larva may bore into several joints during its period of development. When full-grown and ready to pupate, (Pl. I, fig. 5) the larva cuts an opening to the outside that is just large enough for the emergence of the moth. The larva then retires into its burrow and closes the opening to the outside with coarse chips or frass. Behind this loose protection the pupa (Pl. I, fig. 4) is then formed and the transformation to the moth stage occurs. The moth pushes the loose frass aside, or to the outside, and thus escapes during the night. They are ready to lay eggs by the second night.

In the work at Baton Rouge in 1926, the various stages in borer development were recorded on each date as they were found throughout the season. These records were secured principally during the process of cutting up large numbers of stalks of corn and cane throughout the season. (See Pl. II, fig. 3.) This work was free from any abnormal effect that might occur in insectary or laboratory methods of breeding work.

GENERATIONS OF SUGARCANE BORER IN LOUISIANA, 1926
SEASONAL HISTORY



The field examinations show that in 1926 over-wintering moths began to lay eggs for the first generation in the southern part of Louisiana after April 1 and at Baton Rouge after April 15. The first 1926 generation was easily distinguishable and occurred principally between May 1 and June 30. The second generation began about June 15 and ended August 15, by which time the corn crop generally was matured. Thereafter the borers were found principally in cane. The third and fourth generations overlapped decidedly and together covered the period from about August 1 to November 10. The fifth, and hibernating generation, began about October 10 and has continued through the winter. The general distribution of generations for the season of 1926 is shown in the above diagram.

Borer Occurrence in Spring of 1927

In the spring of 1927 full-grown larvæ were found far more abundantly than the year before. The first pupæ were taken in the fields at Baton Rouge on February 9 and 10, which is six weeks earlier than pupæ were found in 1926.

Field examinations made through February and the early part of March have shown a living borer population of at least 1,000 full-grown larvæ and pupæ per acre in a field of stubble cane grown on upland and where the drainage is fairly good. Less than 15% of the larvæ were dead in unburned top trash. The minimum temperature for the winter of 1926 to 1927 at Baton Rouge, Experiment Station, has been only 22 degrees F. and the temperature has been to 32 degrees or lower only seven times during the winter. Most of the mortality found has occurred apparently from water covering the infested stalks in the lower spots rather than from cold.

The borer population in cane and in corn stalks is indicated in the following tables:

SUGARCANE BORER HIBERNATION IN CANE EXAMINATIONS AT BATON ROUGE, 1927.

Date	Variety	Location	No. Stalks	TOPS BURNED Larvae Alive	TOPS BURNED Larvae Dead	TOPS UNBURNED Larvae Alive	TOPS UNBURNED Larvae Dead
1/24	P. O. J. 234	Cut 12, Sq. 3	100	6	7	8	1
1/24	D-74	Cut 8, Sq. 3	100	2	20	17	13
1/24	U.S. Seedlings	Cut 7X	100	4	13	2	5
2/8	(Mixed)	Upland (B.R.)	110	—	—	10	1
2/9	(Mixed)	"	575	—	—	119	12
2/9	(Mixed)	"	180	—	—	14	4
2/10	(Mixed)	"	320	—	—	32	0
2/11	D-74 & Cay. 10	Cinclare	200	13	2	(HAD BEEN BURNED & PLOWED)	
2/11	D-95 & Purple	"	200	0	3		
2/16	(Mixed)	Upland (B.R.)	250	—	—	42	6
2/16	(Mixed)	"	180	—	—	30	3
2/17	(Mixed)	"	415	20	9	—	—
3/4	(Mixed)	"	740	42	39	—	—
TOTALS			3470	87	93	274	45

An examination of the foregoing figures shows that the burning of trash results in a decided increase in the mortality among the borers. Slightly more than half of the larvæ were dead in the burned area while 86% were still alive in the unburned areas. Of course additional mortality will occur in both areas before the emergence is complete. The conclusion appears to be plain that where burning is practiced it should be done as early as possible in the winter in order to secure the maximum control effect upon the borers. So far as total control effect upon borer survival through the winter is concerned, it appears now that plowing and the burial of stalks and trash is far more effective than merely burning over the fields.

So far as we can learn, the possibility of the sugarcane borer passing the winter successfully in old, dry corn stalks has not been considered a serious factor in the borer problem. However, this season it appears that this may be at times, and in some localities, a very important factor when corn stalks are not turned under. An indication of this possibility is shown in the following brief table.

SUGARCANE BORER HIBERNATION IN OLD CORN STALKS EXAMINATIONS AT BATON ROUGE, 1927.

DATE	Approximate Date, Corn Maturity, '26	No. Stalks Exam'd	Row—Distance, Feet	Stages Alive	Stages Dead
2/15	August 15	180	480	4	3
2/23	August 15	133	234	3	1
3/3	August 15	150	417	1	0
3/3	July 30	200	(AFTER PLOWING)	2	0
3/7	August 15	515	1494	5	12
3/8	"Late"	100	102	0	0
3/8	August 15	150	174	6	0
TOTALS		1428	2901+	21	16

The corn examined above was not particularly heavily infested by borers in 1926. The fields were not what would be considered very late in maturity. It is surprising to find so many living borer stages in material that would seem to have been unfit for food for them during a period of more than six months. Evidently the effect of such unfavorable food is to retard greatly the rate of development of the larvæ. It is apparently possible for the life period of a single individual to cover the period from August when the eggs are deposited to the emergence and death of the adult during the following April or May.

It is a well known fact that exceptionally late-maturing corn is subject to extremely heavy infestation. Jones and Bradley record on August 24, 1923, in a field of late corn which was then in tassel and developing ears, as high as 63 larvae and pupae in a single stalk. On September 5, 1923, ten stalks of corn from this field yielded a total of 462 larvæ, pupæ and empty pupal cases. Undoubtedly the chance of winter survival in the stalks of such late-maturing corn is as great as in cane.

The sugarcane borer also hibernates successfully and extensively in rice stubble. At Baton Rouge on January 3, 1923, Mr. T. H. Jones captured 57 sugarcane borer larvae in the crowns and stems of rice stubble. In this same locality all borer larvæ had been found in full-grown stage on November 6 preceding. These larvae were placed on rice stools in cages out of doors and adult moths issued therefrom April 10 to May 15, 1923.

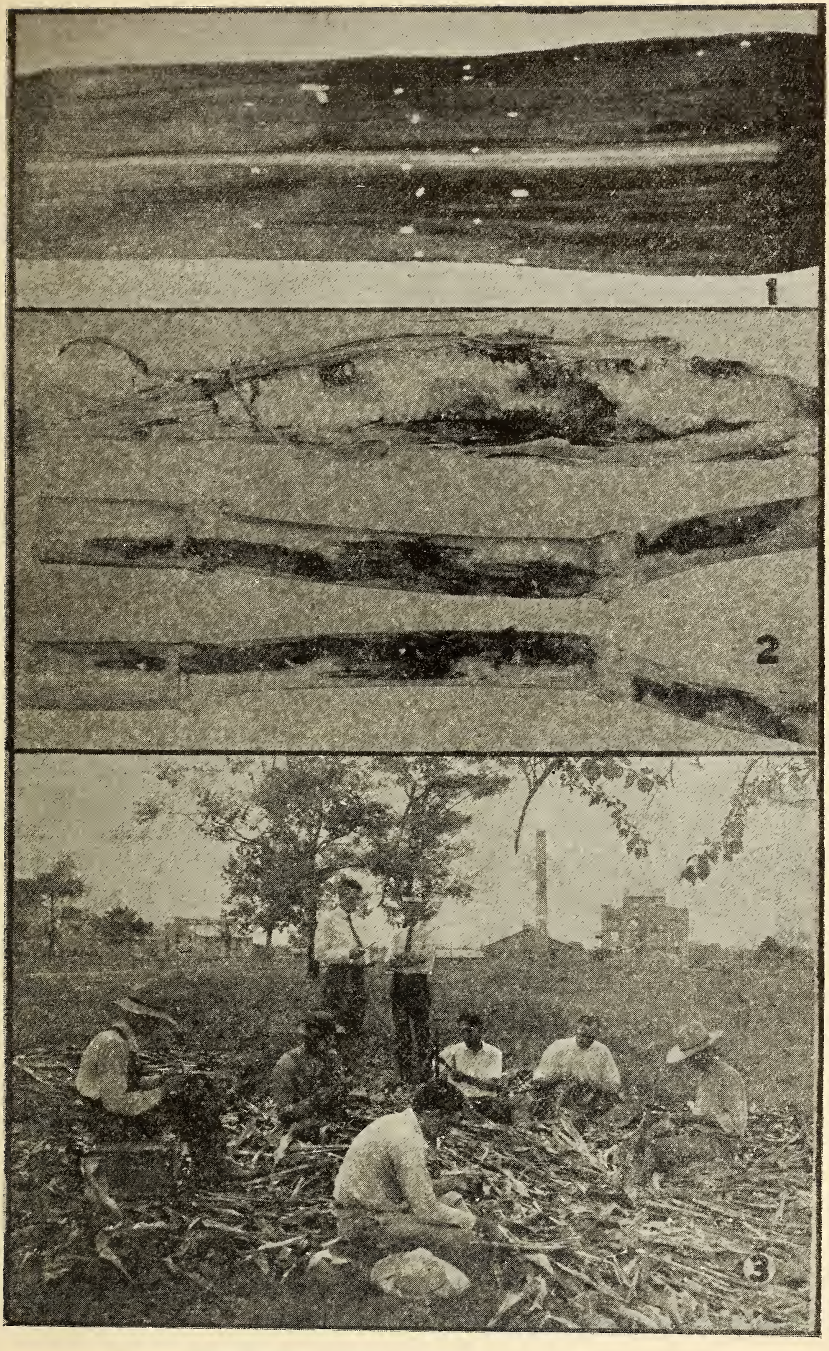
This ability of the borers to hibernate successfully in such materials as old dry corn stalks, rice stubble, and in the stems of Johnson grass and native wild grasses will undoubtedly explain the serious damage which has been sustained frequently in areas producing corn or rice principally but where little, if any, cane is grown within a distance of several miles. These observations show plainly that such trash as may be favorable for sugarcane borer hibernation should be buried as completely as possible before the borer moths emerge therefrom. Undoubtedly such burial may constitute the most effective action that the planter can take in reducing the over-wintering of borers and in preventing damage to both corn and cane early in the season.

Recognizing Young Borer Work on Corn and Cane Leaves

The borer-infested stalks may be picked out easily and very accurately by simply watching the leaves for the signs of the young borer feeding which appear as very small perforations through the blade of the leaf. These tiny holes are usually clean-cut and frequently arranged in groups of from three to five perforations extending in a straight line across the blade of the leaf. (See Pl. II, fig. 1.) This type of feeding work is absolutely characteristic of first stage cane borer larvæ. It can be distinguished easily from the work of the corn ear worm, or cotton boll worm (*Heliothis obsoleta* Fab.) which may also feed in corn particularly producing larger and more ragged holes, but never burrows into the stalk as does the sugarcane borer.

The cane borer moths lay their eggs in batches of from 15 to 50 on either the upper or under surface of the leaves (See Pl. I, fig. 2.) and usually at a point where they approach a horizontal position. The eggs hatch in about a week and the young larvae make their way to the leaf roll of the

Plate II.



Sugarcane Borer Work on Corn

Fig. 1, typical first stage larval feeding effect on leaves; fig. 2, larval work in corn stalks and ears; fig. 3, cutting up corn stalks to determine accurately infestation, stage of borer development, generations and insecticidal control. Photo. fig. 2, by T. H. Jones.

plant. This is undoubtedly their most favorable, and possibly their only successful, feeding place. In the leaf roll these first stage larvæ feed usually by boring straight through the roll at a number of points where the tissue is very tender. When the leaves unroll these feeding places will appear in the characteristic regular transverse arrangement noted above.

As the larvæ grow larger their feeding work appears on the somewhat older leaves close to the roll and is likely to be more irregular in outline and may extend entirely through the leaf or with the epidermis of the leaf left intact on one surface. Third stage larvæ frequently burrow into the mid-rib of a recently unrolled leaf and their feeding there so weakens the leaf that it is likely to break down at that point. Borer feeding work on leaves is the first and plainest sign of infestation.

Not All Corn Fields will be Infested

In considering this matter of controlling the borers developing in corn, it is important to know that the infestation is likely to occur only in part of the corn area. The first generation will undoubtedly infest garden corn generally and some of the early planted field corn. It appears that the moths upon emergence go to the corn which is in a stage of growth that is attractive and favorable for the development of the larvæ so that they will reach maturity at about the time that the corn itself is maturing. It appears, as a rule, that corn is attractive when it is growing thriftily and is from 2 to 4 feet in height. The infestation is likely to be heaviest on the outer edges of the corn field and especially on the side toward the source from which the overwintered moths are coming.

In actual practice therefore, it is very easy to keep track of the borer infestation by watching the garden patches of corn and the edges of the fields of early corn and noting approximately what proportion of the stalks show the typical feeding work of the young borers on the upper leaves. This can be watched easily from horseback or while walking through the rows. If more than one stalk in twenty shows borer work, we would consider the infestation as heavy enough to demand control measures. The farm superintendents or overseers should keep close track of this matter and know where borer control work needs to be applied.

Recognizing the Stage of Borer Development in the Stalks

It is important to keep track of the development of the borers in any field of corn so that the infested corn may be removed in time to prevent the emergence of a very large proportion of the moths therefrom. The condition of borer development within the stalks may be found easily by simply splitting open a number of the infested stalks and watching for the occurrence therein of full-grown larvæ, pupæ or empty pupal skins in the butt portions of these stalks. (See Pl. I, fig. 5.) If most of the larvæ are full-grown, but no pupæ are found, it is safe to assume that there is at least a week more time within which infested stalks may be removed gradually, and as they are needed for feed, without allowing moths to mature and emerge. If many pupæ are present, but no empty pupal skins are found, there is no time to be lost in getting rid of the corn. If there are more empty pupal skins found than there are living pupæ and full-grown larvæ, it shows that most of the moths of that generation have already escaped and therefore that the removal of the corn will be proportionately less effective in borer control.

Proper Time to Dispose of Infested Corn

Such examination of the corn stalks as has been described above will show clearly the proper time for disposing of the stalks. The external signs shown in the stage of growth of the corn may be correlated with the borer development fairly closely after a number of examinations have been made.

It appears to be true, as a rule, that the borers reach the pupal stage at about the time that the corn tassels and ears are formed. The injury to a heavily infested stalk is often so great as to prevent the normal development of the ear (Pl. II, fig. 2) and the stalk may be stunted in growth or, in extreme cases, completely killed. Corn should be watched closely for the stage of borer infestation at the time that tasseling begins. It is far better to start rather early than to wait a few days too long in cutting out borer-infested corn. This is particularly important with regard to the first generation.

Control of First Generation is Most Important

It is undoubtedly true that more good can be accomplished with less work by concentrating the borer control effort on corn for the first generation of borers. There are several reasons for this conclusion.

1st—The generation is more clearly defined and definitely localized.

2nd—The number of borers and of infested corn stalks to be dealt with is smaller with this generation than at any other time.

3rd—Reduction in the number of moths emerging from the first generation must necessarily result in a continuing and beneficial reduction throughout the entire season.

4th—The reduction in the first generation can be accomplished, in most cases, without resorting to any special planting of corn for deliberate trapping purposes.

Removing and Disposing of Infested Corn

In 1926 it was found that ordinary plantation labor could be taught in a few minutes to recognize the borer-infested stalks so accurately that more than 90% of the borers could be removed from the corn field usually by cutting out and disposing of only from 5% to 20% of the corn stalks. Uninfested stalks may be left to mature their grain. If more than 25% of the stalks are infested, it will probably be advisable to cut and remove all stalks. Wagons could then be used in removing the large volume of corn that would have to be handled.

Infested stalks should be cut at or just below the surface of the ground as many borers may be found within the first 6 or 8 inches above the ground. If two or three stalks

SUGARCANE BORER
INFESTATION; CORN VS. CANE
MAY, 1926

DATE	LOCATION	CORN			CANE		
1926	La.	Total Stalks	Infested Stalks	% Infestation	Total Canes	Infested Canes	% Infestation
May 4	Baton Rouge	278	0.0	0.0	....	......	....
12	Baton Rouge	128	0.0	0.0	13,658	2	0.01
14	Baton Rouge	....	......	......	696	0	0.0
	Baton Rouge	5755	86	1.49	....	......	....
21	Baton Rouge	....	......	......	5,410	62	1.14
25	Baton Rouge	....	......	......	8,260	30	0.36
26	Baton Rouge	2146	69	3.21	10,354	93	0.89
27	Baton Rouge	7209	351	4.86	....	......	....
28	Baton Rouge	878	10	1.13	2,877	22	0.76
31	Baton Rouge	35	11	31.42	....	......	....
TOTALS		16,429	527	3.20	41,255	209	0.50

SUGARCANE BORER
INFESTATION; CORN VS. CANE
JUNE, 1926

DATE	LOCATION	CORN			CANE		
1926	La.	Total Stalks	Infested Stalks	% Infestation	Total Canes	Infested Canes	% Infestation
June 14	Port Allen	1,419	201	14.16	882	63	7.13
15	Baton Rouge	11,244	287	2.55	....	....	....
16	Baton Rouge	....	....	....	32,000	241	0.75
17	Baton Rouge	3,722	137	3.68	26,683	104	0.38
18	Baton Rouge	4,505	202	4.48	20,707	104	0.50
19	Baton Rouge	1,600	76	4.75	600	0	0.00
21	Lobdell	700	116	16.57	8,000	109	1.36
22	Baton Rouge	2,208	253	11.45	....	....	....
23	Baton Rouge	5,300	88	1.66	....	....	....
24	Baton Rouge	14,099	153	1.08	....	....	....
25	Lobdell	1,000	15	1.50	11,700	350	2.98
29	Brusly	3,356	113	3.36	18,214	205	1.12
30	Brusly	3,491	22	0.63	26,898	69	0.25
TOTALS		52,644	1,663	3.15	145,684	1,245	0.85

are standing very closely together in the same hill, it may be advisable to cut all stalks in the hill as some half-grown borer larvæ may crawl along the overlapping leaves from the originally infested stalk which shows the leaf perforations to an adjacent stalk which will not show the feeding work of the young larvæ.

In field practice a workman can watch two rows of corn as he walks along and with a cane knife cut out the infested stalks leaving them lying on the ground between the rows and in favorable position for a second man following to pick them up and carry them to the turn row. Under average 1926 infestation conditions, two men could thus cover about one acre per hour. The infested stalks should be removed from the field the same day that they are cut and their forage value may be saved by feeding them immediately to farm work animals, cattle or hogs.

Special attention must be given to destroying the harder butt portions in which most of the pupæ will occur. If these are not eaten by cattle, they may be fed to hogs, run through a stalk-chopping machine, buried in a deep furrow, or submerged in water so that no moths may emerge therefrom. Where large amounts of corn have to be handled, the forage value may be saved fully and the borers destroyed completely by running the stalks through a chopping machine and into a silo. Stalk shredders may be utilized in some cases.

Insecticidal Control in Corn

Where the corn is not needed for forage or where it is felt that it would be better to treat the borers in the field than to attempt the removal of stalks, the borers may be controlled largely by a hand dusting program. In this case the treatment would be given to accomplish the maximum borer control without regard to the burning of the corn foliage that might result. For this work a straight sodium silicofluoride dust might be used, or if it is desired to reduce the burning effect and sacrifice also a small percentage of borer control, then the commercial material should be mixed with one-tenth of its weight of fresh hydrated lime. The dust may be applied by a knapsack bellows type dusters (such as the American Beauty or Vermorel) or by a rotary fan type duster (such as the Root) which is used commonly in cotton dusting work. Among the manufacturers of sodium silicofluoride are the Virginia-Carolina Chemical Company, the Grasselli Chemical Company, Jungmann & Company, the Superfos Company and many others.

Where corn is dusted in the field it will be advisable to give two or more applications at intervals of from ten to fifteen days for each generation, beginning a week after the first leaf perforations are found. The corn must be examined row by row and a puff of the dust applied to the top of each infested stalk and hill as is shown by the leaf signs which have been described. Considerable burning of the corn must be expected with the materials now available but this injury will be less than that inflicted by the borers if they are not controlled and will not prevent the subsequent use of the fodder and ears for livestock if such use is desired.

In the 1926 experimental tests a single dust application such as has been described above was found to destroy from 60% to 80% of the young borers feeding in the leaf rolls and tops and from 50% to 60% of the larger larvæ which had burrowed into the stalks. The treatment even destroyed a small percentage of the pupæ. It should be expected that with a second application for the same generation a considerably higher degree of control would be secured. The dusted stalks may be left growing in the field to produce whatever grain they may and the ears may be harvested with the general crop. Such treatment will usually require only from three to five pounds of dust per acre and a workman should be able to cover about one acre per hour. The cost for the dusting machine will be about $20.00 but this machine may be used for other insect control problems requiring dusting.

With reference to the foregoing table it should be stated that the percentage found dead at the time the examination was made cannot be considered as a complete record of the kill actually resulting from the treatment. There are

SUGARCANE BORER CONTROL IN CORN BY DUSTING WITH SODIUM SILICOFLUORIDE

(Examined 3 to 5 days after treatment.)

Date Dusted	Material Used	No. of Stalks Exam'd	NO. LARVAE FOUND Alive	Dead	% Dead	Foliage Burning
July 6	Jungmann's "Extra Light"	55	57	112	66	Severe
" 6	Va.-Carolina	37	43	89	67	Severe
" 7	Aluminum fluoride	50	33	81	71	Severe
" 7	Wiarda sod. silicofluoride	48	43	37	45	Severe
" 14	Jung."Ex.Lt."+10% H.lime	56	44	97	69	Slight
" 14	Jung."Ex.Lt."+25% H.lime	50	40	55	58	Slight
" 14	Va.-Carolina	41	17	34	67	Severe
" 14	Cryolite	56	26	44	63	Moderate
" 15	Jungmann's "Light"	52	20	19	49	Severe
" 23	Jungmann's "Light"	62	18	39	68.4	Severe
" 23	Jung. "Lt." + 10% H. lime	49	33	21	38.8	Severe
" 23	Jung. "Lt." + 10% Sulphur	53	25	20	44.4	Severe
" 23	Va.-Carolina	24	8	15	65.2	Severe
" 23	Va.-Carolina + 10% H. lime	59	23	38	61.9	Severe
	TOTALS	692	430	701	62.	

several reasons for this statement. First, the killing effect of sodium silicofluoride applications was found to be distributed over a period of more than two weeks and in spite of the occurrence of as much as three (3) inches of rainfall during this period. If examinations were made within the first three or four days after the treatment, the percentage found dead would be lower than the actual kill because the time elapsed had been insufficient to allow for the full effect to be shown. The maximum percentages of dead larvæ were found usually when examinations were made five or six days after the dust was applied. It was evident that after this time many of the first and second stage larvæ which had been killed in the tops of the plants had completely disappeared through decomposition, the growth of the plant, effect of winds, rains, etc. Furthermore, some of the larger stages which were among the first killed in their burrows would be so decomposed that the remains were not recognized. Second, in the handling of stalks during the process of cutting them up for these close examinations many of the dead stages in the tops would become displaced and lost. Living larvæ were practically all located and their relative proportion as recorded would therefore be much higher than the proportion of dead larvæ found.

It appears therefore that the percentage of dead larvæ shown in the foregoing table is a very conservative figure and undoubtedly indicates a considerably lower degree of control than actually occurred in this work.

SUGARCANE BORER CONTROL ON CORN BY DUSTING SHOWING KILL FOR EACH LARVAL STAGE

Baton Rouge, La., July 6-10, 1926, and July 13-19, 1926.

Material Used	LARVAL STAGE or "INSTAR"									
	1st		2nd		3rd		4th		5th	
	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead
Va.-Car. Sod. sifl.	0	4	6	15	2	4	21	42	14	24
% Kill, each stage	100		71		67		67		63	
Jung. "Extra Light"	0	0	4	44	32	43	19	17	1	8
% Kill, each stage	—		92		57		47		89	
Artificial Cryolite	8	5	6	3	33	50	25	7	6	4
% Kill, each stage	38		33		60		22		40	
Alum. silicofl.	0	0	1	10	15	22	15	41	1	8
% Kill, each stage	—		91		59		73		89	
J. "Ex. Lt." — 10% L.	0	0	3	5	14	40	16	40	10	11
% Kill, each stage	—		63		74		72		52	
J. "Ex. Lt." — 25% L.	0	0	4	3	11	12	15	25	9	15
% Kill, each stage	—		43		52		63		63	
Va.-Car. Sod. sifl.	0	0	0	0	12	1	2	18	3	15
% Kill. each stage	—		—		8		90		83	
Artificial Cryolite	0	0	0	0	7	16	4	9	12	19
% Kill, each stage	—		—		69		69		61	
Tot. No., each stage	8	9	24	80	126	188	117	199	56	104
Av. % Kill, each stage	53		77		60		63		65	

From the foregoing table it will be seen that the percentage of kill in each larval stage, with the principal materials tested, is quite consistently uniform. The total number of larvæ recovered was 911 and the average percentage of kill for this entire lot was 63.7%. It is interesting and very important to notice that the average percentage of kill among third, fourth and fifth stage larvæ ranged from 60% to 65%, with an average of over 62%. These stages occurred almost entirely in burrows within the heart of the corn stalks.

Planting Corn for Trapping Borers

According to the best information at present available, special trap plantings do not need to be made in large areas but will be most effective if placed systematically at frequent intervals so that they may be easily accessible for removal from the field and easily accessible also to the moths that may be flying around the cane fields. It seems that corn is most attractive when it is growing luxuriantly in rather thick masses but not necessarily in large areas. Trap corn should therefore be well fertilized with nitrate of soda and kept cultivated as well as is the cane. Scattered single stalks of stunted yellow corn do not constitute a "trap."

For trap purposes, corn may be planted in short strips at or near the corners of cane cuts, in "skips" in the cane rows or along ditch-bank rows. There is no need to duplicate the planting on each side of a cut. It appears now that trap plantings along one ditch row, or across the ends at one turn row, will be sufficient for each cut of cane. Space should be planned however to allow for succeeding plantings of trap corn as they may need to be made. Replanting on the same ground from which corn is removed for one generation will bring the corn into proper growth to attract the moths maturing from the next generation.

It does not appear to be necessary to make any special planting of corn to concentrate the oviposition of the overwintered moths. Advantage should be taken, however, of all corn planted in gardens for early roasting ears and also of all early planted field corn as it occurs. In such corn the major part of the first generation of borers is almost sure to be produced. This early planted corn may be considered altogether as being the first planting for borer concentration.

The second planting of trap corn, to catch the eggs laid by the first spring generation of moths as they emerge from the early corn, should be made at approximately the time that the over-wintering moths are laying most of their eggs. This will be at the time that the feeding work of the first generation young larvæ is seen commonly in the earliest corn. A special trap planting may be made at this time or advantage may be taken of the occurrence of the later planted field corn to concentrate the second generation. The third planting made four or five weeks after the second, or as the first generation moths are active and young borer work appears in the leaf rolls, should be in attractive condition to concentrate the moths of the second generation. At present it appears that it is advisable to make a fourth planting of corn about one month after the third.

It has been suggested that sorghum should be used in place of corn as a trap for borers. However, further observation will be necessary to show whether sorghum is as attractive as corn in Louisiana. Our observations in 1926 failed to show any extensive infestation in sorghum in localities where some varieties of sugarcane even were quite heavily infested at the time. Further tests of various sorghum varieties as attractants in comparison with varieties of corn and cane will be conducted in 1927. Possibly the principal advantage of sorghum, if usable at all, will lie in its capacity for sprouting a new crop after each cutting so that replanting would not be necessary.

It appears at the present time that the stage of growth and the thrifty, rapid-growing condition of corn are probably more important than variety in attractiveness as a borer trap crop. However in 1926, in various locations, some exceptionally heavy infestations were found in fields of pop corn and of Silver Mine corn being grown for roasting ears. It is not yet certain that sweet corn varieties are especially advisable for trap corn planting. From present information it would seem that such varieties as St. Charles White and Creole Yellow may well be used for the earlier plantings and Mexican June corn or Laguna for late-growing trap plantings.

Summarizing the matter of time of planting of corn for trapping cane borers, we believe that the first regularly planted corn in gardens or fields may be depended upon to concentrate the eggs of the over-wintered moths. Special attention should be given to destroying the borers developing in this early corn. The second planting of corn, whether made in regular field practice or deliberately planted as a trap, should be planted at about the time that the feeding work of the young first generation larvæ is seen on the earlier corn. The third and fourth plantings may be made at intervals of from four to five weeks each following the second planting. It is probable that the latest planting should be put into silage or shredded at the proper time for borer control.

Warning must be given against the general practice of planting corn throughout the cane fields where the stands are poor. This practice as often followed provides a very favorable breeding place for the borers but under such conditions that it is very inconvenient, or practically impossible to remove the infested corn from the fields in an economical way. The final effect upon the cane is likely to be disastrous. It would seem that where the stand of cane is too poor to allow a possibly profitable crop it would be better to put in what may be a good crop of soy beans planted either broadcast, alone or interplanted.

Corn Trapping Is Not Entire Solution of Borer Control Problem

It is not expected that the sugarcane borer may be controlled entirely by even the most thorough-going application of these trapping methods applied to corn. There is every reason to believe, however, that this inexpensive and easily applicable plantation work may reduce the first generation of borers in a very important degree and thus reduce the subsequent attack on later corn and on cane throughout the season. If, later in the season, the borer conditions become serious, there will then be every opportunity and reason for applying in addition the insecticidal control measures which may be most advisable on cane.

Conclusions

1. Sugarcane borer moths prefer to lay their eggs on

thrifty-growing corn rather than on cane when such corn is available.

2. The first two generations of borers develop principally in corn in areas where corn is grown at all commonly.

3. A larger proportion of the borer eggs laid on corn produce moths than happens with the eggs laid on cane.

4. Borer hibernation occurs in the larval stage and larvæ survive largely in the top trash which is left exposed on the surface of the ground.

5. Water standing in the furrows and covering such trash kills the borers therein. This water controlling effect is more important than control by low temperatures during most winters in Louisiana.

6. The thorough burial of trash, either before or after burning, is an exceedingly important factor in borer control and should apply to corn stalks as well as to cane trash.

7. Ordinary burning off of trash does not destroy more than one-third of the borer larvæ therein but does expose the surviving larvæ to greater chance of subsequent destruction by water or by unfavorable climatic condition.

8. Burning of trash should be followed by such plowing under of unburned remnants as will prevent the emergence of moths therefrom. Such plowing will be the main dependence in destroying borers hibernating in rice fields or Johnson grass areas.

9. Sugarcane borers produce five or six generations in Louisiana. There was practically no parasitic control on the first two generations on either corn or cane in 1926.

10. The presence of the cane borers is shown first and most plainly by the very small leaf perforations made by the first and second stage larvæ while working in the leaf roll. This work appears more commonly on corn up to about August 1st.

11. Not all corn fields will show borer infestation but certain fields will be found to have concentrated their attack.

12. The stage of borer development, and the proper time for destroying infested corn, is shown clearly by splitting open a number of stalks which show the leaf perforations.

13. More good can be accomplished with less effort by concentrating the control work on the first generation of borers.

14. Infested corn may be identified by ordinary plantation labor and can be removed from the fields and fed green to farm animals or otherwise disposed of so as to prevent the emergence of moths. The uninfested stalks may be allowed to stand and mature their crop of grain.

15. Insecticidal control may be applied to infested corn by hand dusting methods but with considerable burning of foliage with most of the sodium silicofluoride materials now available. Four applications will be necessary to cover development during the first two generations. In 1926 experiments approximately two-thirds of the borers present were destroyed by one application to corn.

16. Sodium silicofluoride applications are dissolved in dews and rains thus washing the entire stalk. An increasing percentage of kill occurs during the first week after application and a diminishing percentage continues for more than another week. This means that a considerably higher degree of control occurs altogether than can be found in any single examination of treated stalks.

17. The percentage of kill among fourth and fifth stage larvæ in corn averaged practically as high as that for the first three larval stages.

18. For concentrating borer oviposition during the first and second generations so that control in corn may be accomplished most economically, advantage should be taken of the regularly planted early garden and field corn or any later planted field corn. These areas may be supplemented and the concentration on corn made more distinct and during a longer period by special planting of trap corn areas.

19. The indiscriminate interplanting of corn in poor stands of cane is not a safe or advisable practice.

20. To constitute a real "trap" corn should be from two to four feet in height, rather closely planted in the row, well cultivated and fertilized and in thrifty growing condition at the time that the borer moths are active and laying their eggs for each generation.

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LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE
AGRICULTURAL EXPERIMENT STATIONS

W. R. DODSON, Dean and Director

BATON ROUGE, LOUISIANA

VARIETY TESTS OF SUGAR CANE
AT
THE SUGAR EXPERIMENT STATION

6 MA '29

BY
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VARIETY TESTS OF SUGAR CANE AT THE SUGAR EXPERIMENT STATION

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In Bulletin No. 1, First Series (1888) Dr. W. C. Stubbs laid down four projects or lines of work for the station, which had just begun to function. Project No. 2 in that list read: "To study the political economy of sugar cane." This expression is elaborated as follows: "It is proposed to test the different varieties of cane in Louisiana and elsewhere. Hon. Norman J. Coleman, Commissioner of Agriculture at Washington, has proffered the services of his department in securing, free of charges, foreign seed for this station."

The work that was then begun was reported on in Bulletins No. 7, 14, 20 and 28, First Series. Bulletin No. 6, Second Series which is partially devoted to variety work, brings out some observations which will answer several questions still being asked by planters interested in the study of varieties. Speaking of the change in physical appearance of sugar canes which had been imported and grown in Louisiana for a few years, Dr. Stubbs says: "A comparison of the records alone would fail to identify most varieties." In a later paragraph: "The gradual diminution in size and increase in sugar content of almost every variety while undergoing acclimation," is noted. And again a most noteworthy observation, which should be remembered by all who attempt to grow or test a new variety of sugar cane, is given. He notes the "impossibility of determining the value of a cane by a few years of cultivation here. This is rendered more apparent each year. Several canes which were very unpromising the first year or two are, by acclimation, yearly improving and may ultimately be usable, and vice versa." A later confirmation of this belief is shown in a letter from Mr. Burgundy LaPice, which is published in Bulletin No. 14. In this letter Mr. LaPice states that his father brought Lapice cane into the state from Java, in 1872, because it tasseled very early, and that when first introduced it was of a bright yellow color, with a very soft rind, very delicate and could not stand cold. After some years of growth in Louisiana, Mr. LaPice found this cane to stand cold as well as any variety; changed color to a greenish yellow, and that the rind had become much thicker.

The next publication on varieties marks a milestone in the subject of varieties. In it we find that through the Department of Agriculture, SEEDLING CANES, from the Royal Agricultural Society of British Guiana, had been secured and successfully grown at Audubon Park. It was in this lot that D74 and D95 came to Louisiana, (1893). On page 5, Bulletin 78, Dr. Stubbs has reported: "At the Louisiana Sugar Experiment Station we have secured and experimented with canes from every available cane sugar portion of the globe, and had not, until the introduction of *seedling canes,* found any of those from tropical countries superior to our home canes, Louisiana Purple and Striped." Four years after receiving these canes the station began distributing them in small quantities, free to all planters who applied for them, and Bulletin No. 78 gives a list of replies to a questionnaire sent out to those who had received seed. It is very interesting to find that James P. Kock, using D74, planted 13 for one, using two stalks and a lap, and 10 for 1 with his D95. J. M. McBride, 1904, ground 850 tons and planted 50 acres; all from one bundle of about 25 stalks received in 1900. Col. J. C. Webster put down all of his for seed, with the exception of a few acres which he sold in the field for $5.00 a ton.

The finding that sugar cane would produce viable seed set many workers throughout the world to producing new varieties of "seedling canes." The Louisiana station entered this work by importing cane seed from tropical countries and germinating them at Audubon Park. For a number of years efforts in this direction met with disappointment. In 1906, R. E. Blouin and his assistant, A. E.

Weller, for the first time outside the tropics, succeeded in germinating cane seed. This work was continued until by 1917 we had secured and tested or had under test 1842 Louisiana seedlings. This work is reported on in Louisiana Bulletin No. 127 by Agee, and in Louisiana Planter, Vol. LXII, No. 2, p. 26, by Taggart.

The quarantine regulations of the Federal Horticultural Board required that all cane should come into this country through their office, and in 1917 we found that we could no longer germinate seed received through Washington. Through correspondence we discovered that the disinfection which these seed received before being released in Washington was fatal to the germinating power, and hence the work was abandoned. However, this work was considered so important that Director Dodson made a trip to Washington, and with the assistance of our representatives in Washington, particularly Senator Edward J. Gay, arranged that the United States Department of Agriculture (Foreign Seed and Plant Introduction) should secure cane seed and germinate them in Washington for us. Later (1920) this service was consolidated with the seedling work of the Office of Sugar Plant Investigations. The Louisiana Experiment Station contributes a nominal sum to the work in Florida, and in return gets a portion of all seedlings secured.

In 1922 the Louisiana station received from Canal Point about 2500 varieties of seedling canes. These were planted at Audubon Park, and the most promising of them were transferred to Baton Rouge in 1923, and continued under test.

The object of this work, method of procedure and detailed description have been fully given by Brandes and Klaphaak in an article, "Breeding of Disease-Resisting Sugar Canes for America," which was published in the Reference Book of the Sugar Cane Industry of the World, July, 1925.

Briefly, the object is to reproduce and elaborate the work done in Java, the original source of the P. O. J. canes.

The 2500 seedlings which were received in 1922 can be divided into twenty-two groups, separated according to parentage. It is of interest to note that in selection based on field observations in growth, and chemical test for sugar content, all of these groups, save four, have been eliminated. The four are:

Kassoer seedlings	U. S. 426 to 1123 Incl.
P. O. J. 213 seedlings	U. S. 1126 to 1719 Incl.
D109 seedlings	U. S. 1721 to 3763 Incl.
D109 seedlings	U. S. 2718 to 3762 Incl.

The Kassoer seedlings in general are very erect, dark green vigorous long jointed canes, but slow in maturing. The P. O. J. seedlings are less erect; in general vigorous canes of better sucrose content, and in them are found the most promising canes of this class. They are not so free of disease as are the Kassoer seedlings, but, like their mother-cane, strongly tolerant. The D109 are larger canes and not merely so tolerant to disease.

These canes have been grown during one very dry year, and through two years of late falls with more than average rainfall. So far none of them have shown qualities that would make them of commercial value. However, many of them are so resistant to disease and capable of producing tonnage with so little effort on the part of the grower, that we are reluctant to give them up without further chance on their part to become acclimated and develop a better sugar producing quality. Table No. 1 shows the records of the U. S. seedlings which we are still growing. Record taken at Audubon Park and Baton Rouge. Mosaic notes taken by Department Plant Pathology.

TABLE I.

U. S. Seedlings

Variety	Date	Brix	Sucrose	Purity	Age	Mosaic
U. S. 429	11- 7-24	16.40	10.36	63.17	P	No
	10-17-25	8.40	3.55	42.25	P	
	12-16-25	13.90	8.73	62.81	S	
	10-16-26	9.8	2.18	22.25	S	
	10-28-26	9.8	4.57	46.63	P	
	12-10-26	11.2	5.33	47.50	P	

TABLE I.—Continued.

Variety	Date	Brix	Sucrose	Purity	Age	Mosaic
U. S. 434	11- 7-24	17.59	11.84	67.31	P	No
	10-14-26	9.90	4.64	46.90	S	
	10-28-26	10.60	5.47	51.60	P	
	12-10-26	11.8	5.97	50.50	P	
U. S. 437	12-14-25	14.30	9.26	64.69	S	No
	11-17-26	11.9	6.21	52.10	P	
U. S. 438	11- 7-24	15.27	9.65	63.19	P	No
	10-19-25	8.50	3.08	36.22	P	
	10-16-26	10.8	5.22	48.33	S	
	10-28-26	10.6	4.82	45.47	P	
	12-10-26	11.5	4.60	40.00	P	
U. S. 452	11-12-23	14.07	6.16	43.78	P	No
	11- 7-24	13.95	8.65	62.00	P	
	10-21-25	9.70	6.64	68.50	P	
	12- 1-25	12.40	6.44	51.94	P	
	10-25-26	9.90	4.27	43.10	S	
	10-28-26	9.93	3.87	41.61	P	
	12-10-26	11.1	4.14	37.2	P	
U. S. 456	11- 7-26	11.7	5.52	47.10	P	No
U. S. 494	11-12-23	13.24	6.23	47.05	P	No
	11-12-24	15.37	9.48	61.67	P	
	10-16-25	9.11	3.67	40.25	P	
	11-28-25	12.40	5.49	44.27	P	
	12-14-25	12.90	5.42	42.01	S	
	10-16-26	10.3	4.56	44.27	S	
	10-28-26	9.8	4.06	41.43	P	
U. S. 510	11- 7-24	16.83	11.05	65.65	P	No
	10-17-25	9.00	3.72	41.40	P	
	12-15-25	12.00	6.11	50.92	S	
	10-15-26	8.60	3.33	38.70	S	
	10-28-26	9.9	3.56	35.96	P	
U. S. 532	11- 7-24	14.39	8.85	61.50	P	No
	10-20-25	9.74	4.06	41.70	P	
	12- 1-25	11.00	4.94	44.91	P	
	12- 4-25	11.40	4.99	43.77	S	
	10-16-26	8.6	2.93	34.07	S	
U. S. 534	11- 7-24	13.62	7.71	56.60	P	No
	10-17-25	11.65	6.80	68.40	P	
	12-14-25	11.05	5.47	49.50	P	
	10-14-26	10.40	4.91	47.20	S	
	10-28-26	8.7	3.33	38.28	P	
U. S. 541	11-12-24	16.03	10.90	67.99	P	No
	10-15-26	8.70	3.30	37.90	S	
	10-28-26	9.1	3.54	38.90	P	

TABLE I.—Continued.

Variety	Date	Brix	Sucrose	Purity	Age	Mosaic
U. S. 547	12-14-25	14.20	9.72	68.45	S	No
	11-17-26	12.1	7.97	65.80	P	
U. S. 559	11-12-24	16.53	11.40	68.96	P	
	11-17-25	10.60	5.36	50.60	P	No
	11-28-25	12.20	6.79	55.66	P	
	10-15-26	9.80	4.57	46.64	S	
	10-28-26	9.9	4.21	42.53	P	
	12-10-26	12.2	5.98	49.01	P	
U. S. 571	11- 7-24	11.31	6.10	53.93	P	No
	11-17-26	12.60	7.44	59.00	P	
U. S. 576	11-12-23	12.94	6.56	50.69	P	No
	11-12-24	15.64	10.90	69.69	P	
	10-20-25	8.33	3.19	38.40	P	
	12- 1-25	12.35	6.27	50.77	P	
	10-15-26	8.8	2.84	32.20	S	
	10-28-26	8.6	2.59	30.12	P	
U. S. 583	10-12-23	12.11	5.21	43.02	P	
	11- 7-24	13.46	8.68	64.39	P	
	10-17-25	8.50	3.72	43.75	P	
	12- 4-25	10.20	5.03	49.31	S	
	10-15-26	9.80	4.72	48.17	S	
U. S. 590	11-12-24	16.07	10.44	64.91	P	No
	10-16-25	7.90	3.49	44.25	P	
	12-12-25	10.60	4.42	41.90	S	
	10-15-26	8.00	2.45	30.63	S	
	10-28-26	10.40	4.23	40.67	P	
U. S. 593	11-12-23	14.21	5.92	41.66	P	No
	11-12-24	15.94	10.83	67.92	P	
	10-17-25	11.70	5.87	50.16	P	
	10-15-26	9.60	4.33	45.11	S	
	10-28-26	11.00	5.72	52.00	P	
U. S. 595	10-19-25	11.05	5.75	52.00	P	No
	11-28-25	12.80	6.62	51.70	P	
	10-14-26	9.20	3.38	36.70	S	
	10-28-26	9.6	3.96	41.25	P	
U. S. 600	11-11-24	14.57	9.56	65.61	P	No
	10-21-25	8.10	4.09	50.40	P	
	12- 1-25	10.20	3.76	36.80	P	
	12-11-25	11.80	6.39	54.15	S	
	12-14-25	13.00	5.32	40.92	S	
	10-15-26	9.50	4.07	43.84	S	
	10-28-26	8.3	2.64	31.81	P	
U. S. 606	10-16-25	9.15	4.15	45.40	P	No
	12- 4-25	13.70	7.38	53.87	S	
	10-16-26	11.50	6.28	54.61	S	
	12-10-26	12.1	6.21	51.3	P	

TABLE I.—Continued.

Variety	Date	Brix	Sucrose	Purity	Age	Mosaic
U. S. 639	11-12-24	14.34	7.76	54.12	P	No
	10-17-25	8.25	3.00	36.40	P	
	12-14-25	11.50	5.60	48.70	S	
	10-14-26	7.60	2.28	30.00	S	
	10-28-26	8.1	3.03	37.41	P	
	12-10-26	10.3	4.31	41.8	P	
U. S. 654	11- 3-24	13.88	9.36	67.40	P	No
	10-21-25	9.65	4.43	45.90	P	
	12- 1-25	12.20	5.72	46.89	P	
	12-11-25	13.30	8.71	65.49	S	
	10-28-26	10.2	4.83	47.35	P	
	12-10-26	11.5	5.15	44.80	P	
U. S. 658	11-15-24	15.37	10.65	69.29	P	No
	10-21-25	8.50	3.23	38.00	P	
	12-11-25	14.60	9.32	63.84	S	
	10-15-26	11.00	5.95	54.09	S	
	10-28-26	10.7	5.55	51.87	P	
U. S. 665	11- 4-24	14.78	10.20	69.10	P	No
	10-20-25	10.70	5.60	52.30	P	
	12-11-25	11.40	5.79	50.79	S	
	10-29-26	10.8	5.92	54.81	P	
U. S. 666	11- 7-24	18.50	14.38	77.51	P	No
	10-21-25	8.85	3.42	38.70	P	
	10-14-26	7.40	1.57	21.20	S	
	10-28-26	9.00	2.31	25.67	P	
	12-10-26	11.9	3.13	26.30	P	
U. S. 667	11- 5-24	15.06	9.45	62.74	P	No
	10-21-25	9.88	4.61	46.70	P	
	12-14-25	12.30	6.95	56.50	S	
	10-16-26	10.7	5.27	49.25	S	
	10-28-26	8.1	2.95	36.42	P	
U. S. 670	11- 7-24	15.13	10.10	66.75	P	No
	10-20-25	10.10	5.05	50.00	P	
	11-28-25	9.70	4.57	47.11	P	
	12-11-25	12.60	7.44	49.05	S	
	10-16-26	9.00	3.50	38.89	S	
	12-10-26	9.9	4.47	45.1	P	
U. S. 672	11-12-24	18.44	13.01	70.55	P	No
	10-18-25	9.60	4.54	47.30	S	
	10-14-26	9.45	3.99	42.2	S	
	10-29-26	11.6	6.42	55.35	P	
U. S. 675	11- 7-24	12.02	6.89	57.31	P	No
	12-11-25	14.30	9.22	65.17	S	
	10-28-26	9.5	4.17	43.90	P	
	12-10-26	10.7	4.30	40.20	P	

TABLE I.—Continued.

Variety	Date	Brix	Sucrose	Purity	Age	Mosaic
U. S. 676	11-15-23	11.93	4.62	38.72	P	No
	12-11-25	15.00	10.31	68.73	S	
	11-17-26	10.6	4.10	38.6	P	
U. S. 681	11- 7-24	13.72	9.36	68.22	P	No
	10-16-25	8.75	3.33	38.10	P	
	12- 4-25	11.00	5.73	52.90	S	
	10-15-26	8.50	3.28	38.59	S	
	12-10-26	10.7	4.87	45.5	P	
U. S. 689	11-15-24	13.96	9.07	64.97	P	No
	10-17-25	9.60	3.76	39.16	P	
	12-14-25	9.50	3.54	32.21	S	
	10-16-26	9.6	4.28	44.58	S	
	12-10-26	11.9	5.53	46.40	P	
U. S. 702	11-12-23	12.01	6.39	53.20	P	No
	11- 6-24	13.05	7.95	60.91	P	
	10-18-25	10.00	5.05	50.50	P	
	12- 9-25	12.70	7.68	60.49	S	
	10-16-26	9.70	3.24	36.00	S	
	12-10-26	10.8	5.10	47.20	P	
U. S. 711	12-15-25	14.20	11.21	78.94	S	No
	11-17-26	12.1	5.96	49.2	P	
U. S. 726	11-12-23	11.94	6.24	52.26	P	No
	11- 6-24	14.89	10.57	67.70	P	
	12- 1-25	11.10	6.66	60.00	P	
	10-15-26	8.30	2.90	34.9	S	
	10-28-26	10.6	4.40	41.51	P	
U. S. 766	11- 3-24	12.78	7.06	55.20	P	No
	11- 5-24	16.06	11.56	71.46	P	
	10-25-25	9.35	4.01	42.90	P	
	10-16-26	10.8	5.62	52.04	S	
	12-10-26	12.8	8.69	72.4	P	
U. S. 794	11-15-23	12.78	5.39	42.17	P	No
	12- 9-25	14.70	10.96	74.56	S	
U. S. 826	11- 6-24	13.75	6.75	49.10	P	No
	10-16-25	13.00	8.35	64.20	P	
	12-15-25	14.20	9.20	64.99	S	
	10-15-26	13.90	9.71	69.90	S	
	10-28-26	10.80	5.25	48.61	P	
U. S. 875	11- 4-24	15.67	10.97	70.00	P	No
	10-21-25	12.60	8.80	69.80	P	
	12- 9-25	14.80	9.15	61.82	S	
	10-16-26	11.80	6.27	53.14	S	
	12-10-26	14.1	8.80	62.4	P	

TABLE I.—Continued.

Variety	Date	Brix	Sucrose	Purity	Age	Mosaic
U. S. 891	11- 5-24	11.14	5.40	48.47	P	No
	10-21-25	8.00	2.74	34.30	P	
	12- 9-25	11.40	5.18	49.30	S	
	10-16-26	8.2	2.80	34.15	S	
	12-10-26	10.6	3.77	35.50	P	
U. S. 897	11-10-24	12.83	8.37	60.52	P	No
	12- 9-25	15.90	10.70	67.30	S	
	11-17-26	11.50	6.39	55.50	P	
U. S. 914	11- 6-24	13.38	8.18	61.20	P	No
	12- 4-25	13.00	8.91	68.54	S	
	11-17-26	12.9	8.33	64.5	P	
U. S. 920	11-10-24	12.63	6.63	52.49	P	No
	12- 9-25	14.30	9.17	64.13	S	
	11-17-26	12.1	7.05	58.2	P	
U. S. 930	11- 9-24	15.68	6.98	44.51	P	No
	12- 5-25	14.40	9.20	63.89	S	
	11-17-26	11.00	5.50	50.00	P	
U. S. 985	11- 4-24	15.39	9.99	64.99	P	No
	10-21-25	12.80	7.91	61.80	P	
	10-28-26	11.70	6.50	55.56	P	
U. S. 988	11- 6-24	13.75	8.16	59.34	P	No
	10-21-25	10.88	6.22	57.20	P	
	10-16-26	8.1	2.88	35.56	S	
	12-10-26	10.9	5.04	48.10	P	
U. S. 1057	11- 6-24	11.54	5.68	49.27	P	No
	10-21-25	8.00	2.83	35.40	P	
	10-16-26	6.4	1.09	17.04	S	
	12-10-26	10.50	3.65	34.70	P	
U. S. 1109	11-17-26	12.0	6.15	51.20	P	No
U. S. 1130	11-15-23	12.87	8.08	62.78	P	No
	11- 5-24	13.05	6.25	47.80	P	
	12- 9-25	13.70	8.48	61.90	S	
	11-17-26	11.7	5.57	47.60	P	
U. S. 1132	11-15-23	10.94	7.03	64.25	P	No
	11- 6-24	14.25	9.69	67.95	P	
	10-21-25	11.15	6.52	58.49	P	
	10-15-26	11.40	6.76	59.30	S	
	12-10-26	12.40	6.44	55.19	P	
U. S. 1137	12-15-23	12.96	7.81	60.27	P	
	11- 9-24	12.46	5.98	47.99	P	
	10-21-25	8.70	4.74	54.48	P	
	12- 9-25	15.00	10.25	68.33	S	
	10-28-26	9.8	4.11	41.96	P	

TABLE I.—Continued.

Variety	Date	Brix	Sucrose	Purity	Age	Mosaic
U. S. 1155	12-11-25	15.30	8.91	58.24	S	No
	11-17-26	12.9	7.03	54.4	P	
U. S. 1159	11-15-23	12.51	8.08	64.59	P	No
	11- 6-24	14.26	8.87	62.20	P	
	10-21-25	10.50	5.75	54.70	P	
	12-10-25	14.00	9.22	65.86	S	
	10-16-26	9.1	3.88	42.64	S	
	12-10-26	11.1	4.84	43.6	P	
U. S. 1175	11-15-23	11.93	7.20	60.35	P	No
	12- 9-25	12.80	7.15	56.17	S	
	11-17-26	12.4	7.36	59.3	P	
U. S. 1210	11-15-23	14.09	9.91	70.33	P	No
	10-20-25	9.70	4.82	49.68	P	
	10-16-26	10.00	4.29	42.90	S	
	10-28-26	8.6	3.02	35.12	P	
U. S. 1382	11-17-26	11.0	5.28	48.00	P	No
U. S. 1387	11- 7-24	15.99	11.76	73.55	P	No
	10-21-25	12.80	8.25	64.45	P	
	12- 1-25	14.50	7.78	53.66	P	
	10-15-26	13.80	9.88	71.60	S	
	11-17-26	12.9	7.19	55.70	P	
U. S. 1399	10-21-25	11.70	7.18	61.40	P	No
	10-15-26	12.30	7.70	62.60	S	
U. S. 1419	11- 4-24	15.57	12.10	77.10	P	No
	10-16-25	10.29	6.01	58.90	P	
	10-14-26	9.00	3.83	42.5	S	
	11-16-26	11.1	5.95	53.60	S	
U. S. 1426	11-12-24	12.92	7.49	57.97	P	No
	12-14-25	11.80	5.47	46.36	S	
	10-29-26	10.8	5.80	53.71	P	
U. S. 1428	11- 7-24	14.63	9.10	62.20	P	No
	10-17-25	11.30	6.91	61.20	P	
	12-14-25	13.70	7.00	51.09	S	
	10-15-26	9.20	3.90	42.4	S	
	12-10-26	13.5	6.49	48.00	P	
U. S. 1437	11-12-23	13.59	7.35	54.09	P	No
	11-17-26	12.8	7.18	56.00	P	
U. S. 1444	11-15-24	17.54	12.97	73.94	P	Yes
	10-16-25	12.48	7.95	63.70	P	
	12- 1-25	11.60	7.22	62.12	P	
	10-15-26	11.20	6.50	58.00	S	
	12-10-26	14.2	9.19	64.70	P	

TABLE I.—Continued.

Variety	Date	Brix	Sucrose	Purity	Age	Mosaic
U. S. 1450	11-10-24	14.37	9.04	62.90	P	No
	12- 1-25	12.60	6.81	54.05	P	
	10-28-26	11.1	5.30	47.75	P	
U. S. 1454	12- 5-25	15.50	10.90	70.32	S	No
	11- 7-26	13.4	8.50	63.40	P	
U. S. 1475	11-10-24	16.97	11.17	65.82	P	No
	12- 1-25	11.50	4.53	39.39	P	
	10-15-26	8.2	2.78	33.9	S	
U. S. 1489	11-12-23	13.65	8.20	60.07	P	No
	11-12-24	17.24	12.64	73.31	P	
	10-14-26	8.60	2.98	34.7	S	
	12-10-26	12.1	6.21	51.3	P	
U. S. 1513	11-12-23	13.81	6.12	44.31	P	No
	11- 6-24	15.63	10.93	69.92	P	
	11-17-26	13.4	8.47	63.2	P	
U. S. 1517	11-12-23	13.74	6.12	44.54	P	No
	11-17-26	12.5	7.26	58.00	P	
U. S. 1532	11-12-24	15.33	11.34	73.97	P	No
	10-19-25	12.50	8.55	68.40	P	
	10-14-26	9.80	4.75	48.50	S	
	11- 9-26	12.1	7.47	61.74	S	
	12-10-26	13.0	8.08	62.1	P	
U. S. 1594	11-12-23	14.49	7.00	48.3	P	No
	11-17-26	12.1	6.80	56.1	P	
U. S. 1613	12-17-26	12.7	7.28	57.3	P	No
U. S. 1679	11- 5-24	15.89	11.24	70.73	P	No
	11-28-25	11.70	5.88	50.26	P	
	10-14-26	9.65	3.89	40.30	S	
	12-17-26	12.2	8.10	66.3	P	
U. S. 1682	11-15-24	14.73	10.18	69.00	P	No
	10-26-25	9.28	4.74	51.07	P	
	12-17-26	11.7	6.21	53.00	P	
U. S. 1687	11- 4-24	14.44	9.88	68.40	P	No
	12-15-25	12.7	6.94	54.65	P	
	11-17-26	13.8	8.74	63.3	P	
U. S. 1694	11-12-23	13.64	5.87	43.03	P	No
	12-14-25	13.00	6.96	53.54	S	
	12-10-26	12.0	5.31	44.2	P	
U. S. 1703	11- 4-24	16.90	12.79	57.60	P	Yes
	10-19-25	12.35	8.27	66.9	P	
	10-14-26	11.10	5.82	52.42	S	
	11-17-26	13.9	8.70	62.5	P	

TABLE I.—Continued.

Variety	Date	Brix	Sucrose	Purity	Age	Mosaic
U. S. 1712	11- 5-24	17.78	13.97	78.57	P	Yes
	10-19-25	13.45	9.52	70.80	P	
	11-12-25	13.60	10.24	75.29		
	10-14-26	12.10	7.69	63.6	S	
U. S. 2169	11- 2-25	11.2	8.24	72.90	P	Yes
	10-28-26	11.4	5.78	50.70	P	
U. S. 2449	10-16-25	11.7	7.27	62.2	P	Yes
	10-28-26	11.0	5.98	54.36	P	
	12-10-26	10.7	6.16	57.40	P	
U. S. 2543	12-14-25	14.4	9.19	63.82	P	No
	11-17-26	11.9	6.33	53.1	P	
U. S. 3032	11- 7-23	13.91	8.90	63.98	P	Yes
	12-10-26	12.8	7.01	54.7	P	
U. S. 26X	11-28-25	12.1	6.25	49.60		No
	12- 4-25	10.8	5.85	54.17		
	10-14-26	7.70	2.38	30.9	S	
	11-30-26	12.3	8.00	65.04	P	
	12-17-26	11.9	5.51	46.30	P	

P = Plant Cane.

S = Stubble Cane.

CANAL POINT SEEDLINGS

In an effort to follow the Java work still further and to get varieties of sugar cane with less of the wild blood and more of the noble type blood, another series of canes was bred by the Office of Sugar Cane Investigations. These were put out under the name of C. P. Seedlings. In the spring of 1925, the Louisiana station received from Canal Point, Florida, 543 varieties of C. P. seedling canes. According to Dr. P. J. Klaphaak these canes can be divided into five groups as follows:

Kassoer X F. M. 3—C. P. 82-122, 154-345.

Tekcha X F. M. 3—C. P. 25-81, 123-153.

Thin seedlings, Java Blood—C. P. 360-361, 384-387, 389-390, 443-444, 587, 650-671.

D109 seedlings—C. P. 357-359, 371-383, 403-442, 451-586, 588-649.

Other heavy canes—C. P. 1-3, 6-7, 346-356, 362-370, 388, 391-402, 445-450, 672.

In the spring of 1926 the Louisiana station received from Canal Point, Florida (Office of Sugar Cane Investigations) another lot of Canal Point seedlings. This shipment contained 147 C. P. varieties.

In the Canal Point seedlings, particularly those which were received in the year 1925, we have some truly beautiful canes. While the analyses so far are low, by comparison with the old standard varieties which are given further on, we see that some of them, like C. P. 13, 17, 47 and 57 are not so low in sucrose as to make them outside the realm of hope. In judging these canes in the light of the information at hand, it must be remembered that the fall of the two years in which we have grown them, have been especially conducive to late growth, hence late maturity.

Mosaic notes taken by Department Plant Pathology.

TABLE II.

Canal Point Seedlings

Variety		Date	Brix	Suc.	Purity	Mosaic	Dia.	Stool	Habit
No. 1	P	10-22-25	10.8	5.35	49.1	No	M	M	Erect
	P	12- 3-25	13.0	7.75	59.46				
	S	10-20-26	11.0	5.48	49.82				
	P	12- 1-26	12.0	6.48	54.0				
No. 2	P	10-22-25	11.25	6.45	57.3	No	M	G	Erect
	P	12- 3-25	13.3	8.46	63.6				
	S	10-20-26	11.6	6.28	54.14				
	P	12- 1-26	12.2	6.77	55.49				
No. 3	P	10-22-25	11.75	6.82	58.1	No	S	M	Erect
	P	12- 3-25	13.2	6.68	49.84				
	S	10-20-26	12.4	7.57	61.05				
	P	12- 1-26	12.4	5.59	45.08				
No. 10	P	10-22-25	10.65	6.00	56.3	No	M	G	Erect
	P	12- 3-25	11.1	6.33	57.02				
	S	10-20-26	11.9	7.19	60.42				
No. 13	P	10-22-25	13.5	8.95	66.29	No	M	M	Erect
	S	10-20-26	12.9	8.08	62.64				
	P	12- 7-26	13.3	8.06	60.6				
No. 15	P	10-20-25	11.3	5.85	51.8	No	S	G	Erect
	P	12- 3-25	11.5	6.35	55.21				
	S	10-20-26	13.55	8.56	63.41				
	P	12- 7-26	13.2	7.96	60.13				

TABLE II.—Continued.

Variety	Date	Brix	Suc.	Purity	Mo-saic	Dia.	Stool	Habit
No. 17 P	10-22-25	11.95	7.62	63.8	No	M	G	Erect
P	12- 3-25	12.8	7.66	59.84				
S	10-20-26	11.7	7.09	60.6				
P	12- 7-26	12.7	7.19	56.61				
No. 19 P	10-22-25	10.85	5.47	50.5	No	M	G	Erect
P	12- 3-25	12.5	7.27	58.16				
S	10-20-26	12.4	7.10	57.26				
P	12- 7-26	12.2	7.42	60.81				
No. 20 P	10-22-25	10.25	4.93	48.1	No	M	M	Erect
P	12- 3-25	11.0	5.67	51.53				
P	12- 8-26	11.5	6.4	55.65				
No. 21 P	10-22-25	12.2	6.97	57.2	No	M	M	Erect
P	12- 3-25	11.1	6.61	59.54				
S	10-20-26	12.7	7.25	57.09				
P	12- 1-26	11.4	6.7	58.77				
No. 22 P	10-22.25	12.25	7.35	60.00	No	M	G	Erect
S	10-20-26	12.1	6.58	54.38				
P	12- 1-26	12.0	6.90	57.5				
No. 24 P	10-22-25	11.0	5.98	54.36	No	M	M	Erect
S	10-20-26	12.3	7.04	57.24				
P	12- 1-26	12.8	7.66	59.84				
No. 30 P	12-22-25	10.7	5.65	52.8	No	M	G	Erect
P	12- 3-25	10.4	6.01	57.78				
S	10-20-26	10.8	5.61	51.95				
P	12- 7-26	13.0	8.28	63.69				
No. 32 P	10-22-25	11.0	6.28	57.1	No	L	G	Lodged
S	10-21-26	11.2	5.98	53.39				
P	12- 7-26	10.5	5.76	54.85				
No. 33 P	10-20-25	10.9	6.35	58.3	No	M	M	Erect
S	10-21-26	11.9	7.42	62.35				
P	12- 7-26	12.2	7.45	61.06				
No. 34 P	10-22-25	12.8	8.58	67.03	Yes	S	G	Reclining
P	12- 7-26	14.1	9.44	66.95				
No. 35 P	10-22-25	11.8	7.04	59.66	Yes	S	M	Erect
S	10-20-26	11.7	6.84	58.47				
P	12- 7-26	12.5	6.95	55.6				
No. 36 P	10-22-25	11.45	6.79	59.3	No	M	G	Erect
P	12- 3-25	11.9	6.94	58.31				
S	10-20-26	11.4	6.66	58.42				
P	12- 8-26	12.4	7.57	61.4				
No. 39 P	10-22-25	11.1	9.8	88.1	No	T	M	Erect
P	12- 1-26	13.8	9.08	65.79				

TABLE II.—Continued.

Variety	Date	Brix	Suc.	Purity	Mosaic	Dia.	Stool	Habit
No. 41 P	10-22-25	11.3	6.4	57.0	No	M	G	Reclining
P	12- 3-25	15.0	10.6	71.2				
S	10-20-26	12.0	7.19	59.92				
P	12- 2-26	11.9	6.53	54.87				
No. 43 P	10-22-25	10.0	4.98	49.8	No	M	G	Erect to Reclining
P	12- 3-25	12.3	6.65	54.14				
S	10-20-26	11.0	6.3	57.27				
P	12- 7-26	11.5	6.15	53.37				
No. 45 P	10-22-25	11.6	5.57	48.00	No	S	G	Reclining
P	12- 3-25	12.1	7.0	58.3				
S	10-21-26	13.0	7.76	59.69				
P	12- 8-26	11.9	6.89	57.89				
No. 46 P	10-22-25	11.0	6.05	55.0	Yes	M	M	Reclining
P	12- 3-25	13.3	8.3	62.3				
S	10-20-26	12.1	7.24	59.84				
P	12- 7-26	12.6	7.21	57.22				
No. 47 P	10-22-25	12.8	8.33	65.07	No	S	G	Reclining
S	10-21-26	13.1	8.26	63.05				
P	12- 7-26	13.0	8.36	64.30				
No. 48 P	10-22-25	11.4	6.74	59.1	No	M	G	Erect
P	12- 6-26	12.2	7.17	58.77				
No. 49 P	10-22-25	10.05	4.78	47.6	No	S	G	Erect
P	12- 3-25	11.4	6.2	54.4				
S	10-21-26	12.9	7.54	58.45				
P	12- 8-26	12.6	7.07	56.11				
No. 50 P	10-22-26	11.08	7.8	70.8	Yes	M	M	Erect
P	12- 3-25	12.9	7.5	58.13				
S	10-21-26	11.0	5.65	51.37				
P	12- 1-26	11.3	5.92	52.38				
No. 52 P	10-22-25	9.3	4.42	47.5	No	M	G	Erect
S	10-21-26	11.8	6.7	56.78				
P	12- 1-26	11.2	5.87	52.41				
No. 54 P	10-22-25	11.4	8.43	73.9	Yes	M	P	Lodged
P	12- 3-22	12.2	7.3	59.9				
S	10-21-26	11.8	7.42	62.88				
P	12- 8-26	12.1	7.14	59.0				
No. 56 P	10-22-25	10.2	5.16	50.5	Yes	S	G	Erect
S	10-21-26	11.4	6.19	54.29				
P	12- 2-26	11.0	6.18	56.18				
No. 57 P	10-22-25	12.0	8.94	74.4	Yes	M	G	Erect
P	12- 3-25	12.5	7.5	62.0				
S	10-21-26	13.5	8.9	55.93				
P	12- 7-26	12.5	7.7	61.6				

TABLE II.—Continued.

Variety	Date	Brix	Suc.	Purity	Mo-saic	Dia.	Stool	Habit
No. 60 P	10-22-25	11.5	8.63	75.0	Yes	M	M	Erect
S	10-20-26	11.1	5.05	45.5				
P	12- 7-26	11.3	6.43	56.9				
No. 61 P	10-22-25	10.1	6.43	63.7	Yes	M	G	Lodged
S	10-20-26	10.3	5.08	49.32				
P	12- 7-26	10.5	4.9	46.66				
No. 62 P	10-22-25	11.25	6.66	59.2	No	M	M	Erect
P	12- 4-25	12.3	7.5	61.0				
S	10-20-26	12.3	7.65	62.2				
P	12- 7-26	12.9	7.8	60.46				
No. 64 P	10-22-25	9.2	4.04	43.91	No	L	M	Erect
S	10-20-26	10.6	5.55	52.36				
P	12- 1-26	11.7	6.41	54.78				
No. 65 P	10-22-25	10.6	5.4	48.6	No	M	G	Reclining
S	10-20-26	10.9	5.98	54.86				
P	12- 1-26	11.5	5.92	51.47				
No. 67 P	10-23-25	11.65	7.29	62.57	No	S	G	Erect
S	10-20-26	13.00	8.33	60.36				
P	12- 1-26	10.1	4.33	42.87				
No. 70 P	10-23-25	11.55	6.74	58.35	No	M	G	Lodged
S	10-20-26	11.1	5.48	50.27				
P	12- 2-26	12.8	8.45	66.01				
No. 71 P	10-23-25	10.55	6.15	58.29	No	S	G	Reclining
P	12- 4-25	12.6	9.02	73.00				
S	10-20-26	12.00	7.65	62.92				
P	12- 2-26	12.1	7.32	59.65				
No. 73 P	10-23-25	10.95	5.98	54.61	Yes	S	G	Lodged
P	12- 4-25	12.2	7.1	58.2				
S	10-20-26	12.3	7.36	59.84				
P	12- 7-26	11.5	6.76	58.78				
No. 74 P	10-23-25	11.75	7.82	58.04	Yes	M	M	Erect
P	12- 4-25	11.3	5.87	51.84				
S	10-20-26	11.1	6.59	59.37				
P	12- 8-26	12.8	7.39	58.65				
No. 75 P	10-23-25	12.0	7.8	65.00	No	S	G	Erect
S	10-20-26	12.2	9.05	65.98				
P	12- 7-26	11.7	6.89	58.88				
No. 77 P	10-23-25	9.16	4.19	45.60	Yes	M	G	Erect
P	12- 4-25	10.7	5.62	62.52				
S	10-20-26	10.4	6.47	62.21				
P	12- 6-26	11.2	5.83	52.05				
No. 79 P	10-23-25	11.2	5.83	52.10	No	M	M	Reclining
P	12- 4-25	11.5	6.5	56.50				
S	10-20-26	10.9	5.83	53.48				
P	12- 1-26	11.5	6.22	56.54				

TABLE II.—Continued.

Variety	Date	Brix	Suc.	Purity	Mo-saic	Dia.	Stool	Habit
No. 80 P	10-23-25	11.05	6.25	56.6	No	M	M	Erect
P	12- 4-25	11.9	6.10	51.30				
S	10-20-26	12.5	7.16	57.28				
P	12- 1-26	11.7	6.37	54.44				
No. 81 P	10-23-25	9.65	4.11	42.6	Yes	M	G	Erect
P	12- 4-25	12.0	7.00	58.3				
P	12- 1-26	11.3	6.25	55.3				
No. 89 P	10-23-25	9.5	4.22	44.4	No	M	M	Erect
P	12- 4-25	11.4	5.72	50.17				
S	10-20-26	9.0	3.53	39.23				
P	12- 2-26	10.7	5.17	48.31				
No. 109 P	10-23-25	11.35	6.05	53.3	No	S	G	Erect
S	10-21-26	10.9	5.23	47.99				
P	12- 8-26	11.8	6.5	55.08				
No. 110 P	10-23-25	10.8	5.65	52.3	No	S	G	Erect
S	10-21-26	10.9	5.19	47.62				
P	12- 1-26	11.9	6.85	57.56				
No. 123 P	10-23-25	10.5	5.81	55.3	No	M	M	Erect
S	10-20-26	9.8	4.46	45.51				
P	12- 7-26	11.3	6.69	59.2				
No. 124 P	10-23-25	12.1	7.3	60.3	Yes	S	M	Erect
S	10-20-26	12.2	7.41	60.74				
P	12- 7-26	13.1	7.91	60.38				
No. 125 P	10-23-25	10.1	5.65	51.83	No	M	G	Lodged
S	10-20-26	10.7	4.94	46.17				
P	12- 7-26	13.3	8.11	60.97				
No. 128 P	10-23-25	11.7	6.98	50.65	No	M	M	Lodged
S	10-21-26	11.1	5.7	51.35				
P	12- 7-26	12.6	7.68	60.95				
No. 129 P	10-23-25	11.88	6.40	58.5	Yes	S	G	Reclining
No. 130 P	10-23-25	11.3	7.13	63.1	No	M	P	Reclining
S	10-21-26	12.6	7.95	63.10				
P	12- 2-26	12.8	8.92	69.68				
No. 131 P	10-23-25	11.2	6.59	58.8	No	S	M	Erect
S	10-21-26	11.7	7.64	64.44				
P	12- 2-26	11.4	6.92	60.7				
No. 132 P	10-23-25	11.5	6.35	55.2	No	M	G	Reclining
S	10-21-26	11.5	6.39	55.56				
P	12- 2-26	12.4	7.10	57.25				
No. 134 P	10-23-25	10.2	5.85	57.0	No	M	M	Lodged
P	12- 2-26	12.4	7.9	63.7				

TABLE II.—Continued.

Variety		Date	Brix	Suc.	Purity	Mo-saic	Dia.	Stool	Habit
No. 135	P	10-23-25	10.9	6.65	60.1	Yes	L	M	Reclining
	S	10-21-26	10.7	5.85	54.67				
	P	12- 7-26	14.2	9.39	66.12				
No. 136	P	10-23-25	10.9	6.17	56.1	No	M	G	Erect
	S	10-21-26	11.6	5.95	54.09				
	P	12- 7-26	12.5	7.02	56.16				
No. 138	P	10-23-25	11.5	6.98	60.7	No	L	G	Lodged
	S	10-21-26	11.2	6.10	54.46				
	P	12- 7-26	10.9	4.84	44.6				
No. 143	P	10-23-25	11.2	6.94	61.96	No	S	M	Erect
	S	10-21-26	11.8	7.22	61.2				
	P	12- 8-26	13.2	8.36	63.33				
No. 150	P	10-23-25	10.15	5.37	52.9	No	M	G	Erect
	S	10-21-26	11.8	7.15	60.59				
	P	12- 2-26	13.7	9.29	67.81				
No. 152	P	10-23-25	13.1	8.53	65.11	Yes	S	G	Erect
	S	10-21-26	13.5	9.05	67.03				
No. 159	P	10-23-25	9.8	4.73	48.3	No	S	G	Reclining
	S	10-21-26	11.9	6.77	56.89				
	P	12- 8-26	12.1	6.65	54.95				
No. 177	P	10-23-25	9.3	3.53	37.9	No	M	G	Erect
	S	10-21-26	11.0	6.08	55.27				
	P	12- 2-26	11.4	5.23	45.87				
No. 178	P	10-23-25	8.5	4.00	47.1	No	S	G	Reclining
	S	10-21-26	11.3	6.64	58.77				
	P	12- 2-26	11.1	6.54	58.91				
No. 200	P	10-30-25	9.65	4.88	50.6	No	S	M	Reclining
	S	10-21-26	8.2	2.9	25.4				
	P	12- 2-26	10.9	5.92	54.31				
No. 204	P	10-27-25	10.0	5.76	57.6	No	S	G	Erect
	S	10-21-26	12.5	8.4	67.2				
	P	12- 2-26	11.4	6.74	59.12				
No. 205	P	10-27-25	11.1	6.35	57.2	No	M	G	Lodged
	S	10-21-26	11.2	6.13	54.33				
	P	12- 2-26	9.2	4.35	47.28				
No. 206	P	10-27-25	8.9	4.78	53.7	No	M	M	Erect
	S	10-21-26	10.0	5.51	55.10				
	P	12- 7-26	11.2	6.81	60.80				
No. 212	P	10-27-25	8.8	4.22	48.00	No.	S	G	Erect
	S	10-21-26	9.8	5.27	53.78				
No. 221	P	10-27-25	11.1	5.95	53.6	No	S	M	Erect
	S	10-21-26	10.6	5.50	51.89				
	P	12- 1-26	11.2	6.46	54.28				

TABLE II.—Continued.

Variety	Date	Brix	Suc.	Purity	Mosaic	Dia.	Stool	Habit
No. 222 P	10-27-25	11.5	7.02	60.9	No	M	M	Erect
S	10-21-26	11.4	6.56	57.54				
P	12- 1-26	11.2	5.83	52.05				
No. 239 P	10-28-25	10.3	4.6	44.66	No	M	G	Erect
S	10-21-26	10.8	5.52	51.1				
P	12- 7-26	10.9	4.77	43.76				
No. 256 P	10-28-25	10.55	5.62	53.3	No	S	G	Reclining
S	10-21-26	10.9	6.15	56.43				
P	12- 2-26	10.9	5.00	45.87				
No. 258 P	10-28-25	10.6	5.85	55.2	No	M	G	Reclining
S	10-21-26	8.8	3.88	44.09				
P	12- 2-26	10.0	4.96	49.6				
No. 268 P	10-28-25	11.9	7.62	64.0	No	S	M	Lodged
S	10-22-26	11.6	6.72	57.93				
P	12- 8-26	11.6	6.81	58.7				
No. 290 P	10-28-25	10.5	4.73	47.1	No	M	G	Lodged
S	10-26-26	10.4	5.45	52.4				
P	12- 2-26	10.1	4.36	43.16				
No. 307 P	10-28-25	10.45	5.73	52.3	No	M	G	Lodged
S	10-26-26	11.7	6.82	58.29				
P	12- 6-26	11.2	6.10	54.46				
No. 324 P	10-28-25	11.55	6.7	58.00	No	S	G	Reclining
S	10-26-26	11.00	6.18	56.18				
P	12- 2-26	12.1	6.31	51.32				
No. 351 P	10-28-25	10.8	5.04	46.7	No	L	P	Erect
S	10-25-26	11.1	5.98	53.87				
P	12- 1-26	12.8	8.23	64.29				
No. 358 P	10-28-25	11.8	6.75	57.2	Yes	L	P	Erect
S	10-25-26	13.4	8.65	64.55				
P	12- 1-26	13.0	8.18	62.92				
No. 366 P	10-28-25	11.2	6.23	65.6	No	S	G	Reclining
S	10-25-26	11.9	7.75	65.12				
P	12- 2-26	13.0	8.06	62.00				
No. 395 P	11- 2-25	9.1	3.64	40.00	No	XL	M	Erect
S	10-25-26	10.4	3.87	37.21				
P	12- 8-26	10.8	5.2	48.14				
No. 412 P	11- 2-25	12.6	7.75	61.4	Yes	M	P	Reclining
S	10-25-26	12.25	6.91	55.39				
No. 447 P	12- 2-25	10.7	5.37	50.2	No	L	M	Reclining
S	10-27-26	12.2	8.20	67.31				
No. 545 P	11- 2-25	13.4	8.13	60.7	No	M	M	Erect
S	10-27-26	12.0	6.97	58.08				

TABLE II.—Continued.

Variety	Date	Brix	Suc.	Purity	Mosaic	Dia.	Stool	Habit
No. 582 P	11- 3-25	12.55	7.42	59.11	Yes	L	P	Erect
S	10-26-26	11.6	6.09	52.5				
P	12- 2-26	12.3	7.37	59.91				
No. 588 P	11- 3-25	13.5	8.21	62.90	Yes	L	M	Erect
S	10-28-26	11.7	6.42	54.87				
P	12- 2-26	11.9	6.34	56.63				
No. 596 P	11- 3-25	13.10	7.71	58.80	Yes	L	G	Erect
S	10-26-26	13.6	8.42	61.91				
P	12- 2-26	14.00	9.39	67.07				
No. 597 P	11- 3-25	13.65	9.16	67.10	No	XL	G	Erect
S	10-27-26	11.9	6.11	51.34				
P	12- 7-26	12.2	7.30	59.83				
No. 654 P	11- 4-25	12.10	6.77	55.90	No	M	G	Erect
S	10-26-26	12.0	6.38	53.17				
No. 719 P	10-28-26	11.42	4.71	42.05	Yes	T	P	Erect
No. 722 P	10-28-26	12.7	7.09	65.82	No	L	G	Erect
No. 724 P	10-28-26	11.9	6.14	51.59	No*	L	M	Erect
No. 731 P	10-28-26	11.6	6.19	53.36	No	M	M	Erect
No. 739 P	10-28-26	10.7	7.55	70.56	No	L	G	Erect
No. 750 P	10-28-26	12.9	7.56	58.6	No	T	G	Reclining
No. 757 P	10-28-26	12.6	7.14	56.66	No*	M	G	Reclining
No. 758	10-28-26	12.8	7.21	56.32	No	S	G	Reclining
No. 807	10-28-26	13.6	9.36	68.82	No	M	G	Reclining
No. 808	10-28-26	11.2	5.55	49.55	No	L	M	Reclining
No. 810	10-28-26	12.0	6.58	54.84	No	T	G	Reclining
No. 818	10-28-26	11.6	6.12	53.76	No	M	M	Erect
No. 827	10-28-26	11.9	7.04	59.16	No	T	G	Reclining
No. 828	10-28-26	11.4	6.18	54.21	No	T	M	Reclining
No. 830	10-28-26	13.0	7.26	55.85	No*	M	M	Reclining
No. 831	10-28-26	11.4	5.98	52.46	No	M	M	Reclining
No. 843	10-28-26	11.8	5.99	47.38	No	T	M	Erect
No. 909	10-28-26	12.7	7.38	61.26	No	M	G	Erect

*These canes show rust on leaves.

Under diameter five classes or sizes are made.

T = thin
S = small
M = medium
L = large
XL = extra large

Under Stool:

P = poor stool
M = medium stool
G = good stool

P. O. J. CANES

The so-called P. O. J. canes constitute a group of varieties that have attracted a great deal of attention. After finding that canes could be grown from seed, most investigators were content to depend on the laws of chance and take seed of unknown parentage. Such seed might be either self-fertilized or chance crosses. In Java it was found that certain varieties of cane did not have perfect flowers; one might develop a perfect pistil, while another would develop a perfect anther. Under such conditions self-fertilized seedlings could not be had, but by growing these two canes close together, or by artificially transferring the pollen, seedlings of cross-breed with definitely known parentage could be secured. The P. O. J. canes are such canes, and are intentionally bred to possess disease-resistant qualities. The Louisiana Experiment Station has been testing Java seedlings since its beginning, and in Bulletin 127 by Agee a list of such is given. P. O. J. 234 is one that was secured by Agee, and put under test at Audubon Park. The cane which he had under that name was not able to compete at that time with the old well-established varieties, in growth or sucrose. The records show three analyses of that cane. In 1911 it showed 12.00 Brix, 7.00 sucrose and 58.4 purity. In 1912 the analysis was even poorer, 10.9, 4.5 and 41.3 respectively; and in 1914 we find a little better showing in an analysis of 14.00, 9.9, and 70.7. Two canes under J.139 also show in this record; one as No. 1 and the other as No. 2. These canes were of the same color and general habit of growth, but one was a thick cane, and the other a thin cane, neither showing a sucrose content of merit. Evidently No. 36, which was imported at the same time, did not germinate, for there is no record of it in the nursery plants.

After these canes had proved their worth in the Argentine, and on the recommendation of Dr. W. E. Cross, the Sugar Experiment Station began trying to get these varieties into the state, and finally Dr. W. E. Cross shipped to the station several barrels of P. O. J. 36, 213 and 234, along with some cane that was destined for Porto Rico. This shipment was taken over by the Federal Horticultural Board and planted on an island near Miami, Florida. All of the canes, except a little of the 234, developed mosaic disease and were destroyed. In March, 1922, Dr. Brandes shipped to the station at Audubon Park, from Miami, a sack of P. O. J. 234 seed pieces. In June of that same year we received from Dr. Brandes, from Washington, three small seed pieces each of P. O. J. 36 and 213, which he had grown in the hothouse. In 1923 we received P. O. J. 100, 139, 826, 979, 1228 and 2379, all from Dr. Brandes in Washington. In 1925 we received M 36, P. O. J. 2221, 2364, 2714, 2725, 2727. In 1926 we received another lot from Dr. Brandes, including P. O. J. 2221, 2222, 2364, and B. H. 10-12. All of these canes have been given special attention, and their records during the time we have had them, at Audubon Park and Baton Rouge, are given in Table III. No analysis for P. O. J. 2221 and 2222 have been made.

TABLE III.

Java Seedlings

	Analysis					96 Sugar Per Ton	Per Acre	
Seedling No.	Date	Brix	Sucrose	Purity	Age		Tons Cane	Lbs. Sugar
P. O. J. 36	11-12-23	14.63	10.91	74.57	P			
	11- 9-24	17.54	13.39	76.33	P	189		
	10-14-26	10.35	5.71	55.20	S			
	10-25-26	11.20	6.89	61.52	S			
	11- 4-26	10.70	5.90	55.15	S			
	11- 9-26	11.50	6.95	60.43	S			
	11-16-26	11.10	5.80	52.25	S			
	11-16-26	12.20	7.45	61.06	P			
	11-30-26	12.00	7.40	61.66	P			
	12-17-26	12.00	7.77	64.75	P	96	32.51	3120
	Average	12.32	7.81	63.39		96		
P. O. J. 100	10-24-25	11.45	7.63	66.64	P	96		
	11- 4-25	12.20	7.19	58.93	P			
	10-25-26	11.60	6.56	56.55	S			
	11- 4-26	13.20	8.47	64.16	S			
	11- 9-26	12.80	7.96	62.19	S			
	11-16-26	12.80	7.59	59.30	S			
	11-30-26	13.00	7.76	59.67	P			
	Average	12.44	7.59	61.01		90		

TABLE III.—Continued.

Seedling No.	Analysis				Age	96 Sugar Per Ton	Per Acre	
	Date	Brix	Sucrose	Purity			Tons Cane	Lbs. Sugar
P. O. J. 139	10-24-25	9.00	4.03	44.80	P			
	11-28-25	14.60	11.17	76.40	P	158		
	12-16-25	12.50	8.20	65.60	P			
	10-14-26	11.90	6.72	56.50	S			
	11- 9-26	8.90	3.39	38.08	S			
	11- 9-26	11.20	6.44	57.50	S			
	11-30-26	11.00	5.48	49.81	P			
	11-30-26	13.00	8.38	64.46	P			
	12-17-26	8.50	2.94	34.50	P			
	Average	11.18	6.30	56.35		68		
P. O. J. 213	11- 8-23	13.79	7.05	51.12	P			
	11- 9-24	17.14	12.82	74.79	P			
	10-24-25	10.25	6.43	62.70	P			
	12-16-25	13.20	10.34	78.33	P	148		
	10-14-26	9.95	4.77	47.90	S			
	10-25-26	12.10	7.90	65.29	S			
	11- 4-26	12.90	7.62	59.07	S			
	11- 9-26	13.20	9.34	70.76	S	125	30.95	3868
	11-16-26	12.30	7.51	61.05	S			
	11-16-26	12.40	7.85	63.30	P			
	12-17-26	12.30	8.85	71.95	P	120	33.48	4017
	Average	12.69	8.22	64.77		103		
P. O. J. 228	11- 9-24	16.64	14.60	87.74	P	223		
	10-24-25	12.00	7.96	66.30	P			
	11- 4-25	11.90	7.44	62.52	P			
	11-28-25	13.20	9.29	70.30	P	124	27.2	3373
	10-14-26	9.55	4.65	48.70	S			
	10-25-26	9.60	4.58	47.71	S			
	11- 4-26	10.20	4.92	48.23	S			
	11- 9-26	11.70	7.45	63.67	S	91.6	35.69	3269
	11-16-26	10.70	5.55	51.87	S			
	Average	11.72	7.38	62.96		90		
P. O. J. 234	11- -22	14.94	11.29	75.50	P			
	11- 8-23	15.24	8.10	53.15	P			
	11- 9-24	17.04	13.15	77.17	P			
	10-24-25	13.50	10.02	74.20	P			
	11-28-25	14.40	11.58	80.40	P	169	16.0	2704
	10-14-26	12.10	7.12	58.80	S			
	10-25-26	13.20	9.26	70.15	S			
	11- 4-26	14.30	10.40	72.83	S			
	11- 9-26	14.70	11.44	77.82	S	163	23.94	3902
	11- 9-26	13.80	10.03	72.68	P	137	26.72	3661
	Average	14.32	10.24	71.51		138		
P. O. J. 826	11- 9-24	15.74	11.24	71.41	P			
	10-24-25	10.55	6.30	59.71	P			
	11- 4-25	11.80	7.17	60.76	P			
	11-28-25	13.25	9.83	74.10	P	136		

TABLE III.—Continued.

	Analysis					96 Sugar	Per Acre	
Seedling No.	Date	Brix	Sucrose	Purity	Age	Per Ton	Tons Cane	Lbs. Sugar
	12-16-26	10.60	6.62	62.45	P			
	10-14-26	9.15	4.15	45.40	S			
	10-25-26	10.10	5.25	51.98	S			
	11- 9-26	12.90	8.81	68.29	S	115	13.8	1587
	11-16-26	11.10	6.33	57.02	P			
	11-30-26	11.30	6.59	58.31	P	74	34.84	2578
	Average	11.65	7.23	62.06		87		
P. O. J. 979	10-24-25	12.90	9.27	71.80	P	125	32.5	4062
	11- 4-25	12.20	7.10	58.20	P			
	11-28-25	12.35	7.87	63.70	P			
	12-16-25	13.90	9.77	70.29	P			
	10-14-26	11.00	5.87	53.40	S			
	10-25-26	10.00	5.01	50.10	S			
	11- 4-26	12.10	7.61	38.09	S			
	11- 9-26	12.60	7.78	62.54	S	95	19	1805
	11-16-26	12.40	7.31	58.95	S			
	11-16-26	11.80	6.50	55.08	P	69	16.69	1151
	11-30-26	10.60	5.60	52.83	P			
	Average	11.99	7.24	60.38		85		
P. O. J. 1228	10-24-25	11.25	7.35	65.30	P	92		
	12-16-25	10.70	6.67	62.34	P			
	10-14-26	9.10	4.54	49.90	S			
	10-25-26	9.50	4.77	50.22	S			
	11- 9-26	10.20	5.75	56.37	S			
	11- 9-26	11.10	6.64	59.82	S			
	11-16-26	9.20	4.78	51.96	S			
	11-30-26	10.20	5.16	50.58	P			
	12-17-26	8.20	3.52	42.92	P			
	Average	9.93	5.46	54.98		58		
P. O. J. 2364	11- 9-26	11.30	5.92	52.38	S			
	11-16-26	10.90	5.65	51.83	P			
	11-30-26	10.40	5.43	52.21	P			
	Average	10.87	5.66	52.06		56		
P. O. J. 2379	11- 9-24	16.24	12.02	74.19	P	167		
	10-24-25	12.60	8.12	64.50	P			
	11- 4-25	13.30	9.45	71.10	P	128	29.19	3736
	11-28-25	12.00	7.52	62.60	P			
	10-25-26	10.00	4.06	40.60	S	25	27.28	682
	11-14-26	9.90	4.01	40.60	P			
	11-30-26	11.70	6.44	55.04	P			
	12- 7-26	12.80	7.41	57.89	P			
	Average	12.32	7.38	59.90		86		
P. O. J. 2714	11- 9-26	12.70	8.08	63.62	S			
	11-16-26	10.90	5.63	51.65	P			
	11-30-26	11.40	6.30	55.26	P			
	Average	11.67	6.67	57.16		74		

TABLE III.—Continued.

Seedling No.	Analysis				Age	96 Sugar Per Ton	Per Acre	
	Date	Brix	Sucrose	Purity			Tons Cane	Lbs. Sugar
P. O. J. 2725	11- 9-26	13.20	8.87	67.20	S	114		
	11-16-26	13.20	8.83	66.89	P			
	11-30-26	11.70	7.29	62.30	P			
	Average	12.70	8.33	65.59		105		
P. O. J. 2727	11-16-26	12.80	7.42	57.96				
	11-30-26	12.70	7.64	60.15				
	Average	12.75	7.53	59.06		86		

In this table is shown possible yield of 96 test sugar per ton, and where yield per acre is known, pounds of 96 test sugar per acre. These calculations are based on an assumed 75% extraction and reducing the purity of final molasses down to 30. Loss of sugar in process of manufacture is not deducted.

P. O. J. 36, 100, 234, 826, 2379 all show about 100% mosaic disease; while 979, 213, 228, 2221, 2222, as well as the 2700 series, are very resistant or immune to this disease. So far all of these P. O. J. canes have shown great resistance to Root trouble.

It will be noted that P. O. J. 234 is more consistent in maturing, and where both tonnage per acre and sucrose content of cane are known, has produced more sugar per acre in case of 1st year stubble, and in 1926 that P. O. J. 213 leads with plant cane. In 1924 both P. O. J. 36 and 228 made more sugar per ton than did 234. The analysis of P. O. J. 213 in 1924 is hardly comparable with 36 or with the other P. O. J. canes that year. Borer damage to P. O. J. 213 in 1924 was severe and it was not possible to select stalks of it that were not top killed by the pest.

Very attractive canes are found in P. O. J. 2714, 2725, and 2727. These are all large barrel, vigorous growing, disease-resistant canes that are attracting attention wherever mosaic disease is a problem. We have had them in small quantities during the past two seasons and in that time have gotten sucrose tests for one year. P. O. J. 2725 shows a margin of advantage over the other two. They are being propagated as rapidly as possible in order that they may be extended to the test field for further study.

STORM DAMAGE TO P. O. J. CANES

Due to occasional tropical storms, it is well to know the ability of a new cane to stand high winds. The August storm offered an opportunity to observe these new canes under storm conditions. The following table shows percentage of broken stalks for the different varieties at four places within the state.

TABLE IV.

Variety		Baton Rouge % Broken	Reserve % Broken	Raceland % Broken	Glenwood % Broken
D-74	Plant	19.0	19.0	23.0	15.0
D-74	Stubble	5.7	....	....	....
La. Striped	Plant	5.1	....	....	....
La. Purple	Plant	2.0	....	....	....
La. Purple	Stubble	0.0	....	....	....
36-M	Plant	13.4	....	....	....
P. O. J. 36	Plant	12.0	....	....	10.0
P. O. J. 213	Plant	3.0	....	*13.0	....
P. O. J. 228	Plant	1.6	....	5.0	1.0
P. O. J. 234	Plant	0.8	....	....	....
P. O. J. 826	Plant	1.9	....	5.0	....
P. O. J. 979	Plant	49.1	66.0	41.0	45.0
P. O. J. 2379	Plant	1.5	....	12.0	....
P. O. J. 2714	Plant	7.2	....	....	....
P. O. J. 2725	Plant	2.9	....	....	....
P. O. J. 2727	Plant	0.0	....	....	....

Storm damage data at Baton Rouge by Edgerton. At Substation by Rodriguez.

*10% Top breakage, due to borer damage.

OTHER VARIETIES

The final judgment of a new variety of cane can not be based on measurements of its growth and sugar making capacities alone. These figures must be based on some comparison with a standard of known value. In order that we may have a better basis for opinion, we have drawn up a table showing the performance of the old varieties, Louisiana Purple and Striped, D74 and D95 and some others that are of general interest. It is clearly noted that the yields of the native canes as given for the year, are far above what were generally secured from these varieties throughout the sugar belt. It has been our aim to use the best seed of these old varieties that we could secure, in order that the new variety might be forced to beat the old at its best and not have an easy victory over a badly crippled rival. In other words, we believe that a variety to be of value to the sugar industry must do far more than just improve on the general average of the state for the past few years. All of our D74 cane shown in these calculations for tonnage and sugar per acre was grown from mass selected seed, or by eliminating badly diseased seed when cutting for planting purposes, and the Purple and Striped were from the best seed of these canes that we could secure at the time. The P. O. J. canes, U. S. and C. P. seedlings La. Purple and Striped were fertilized with 250 pounds Acid Phosphate and 70 pounds Sulphate Potash, and a crop of Melilotus. D74 received 36 pounds nitrogen in place of melilotus.

TABLE V.

Louisiana Standard Varieties

Variety	Date	Brix	Suc.	Purity	Plant or Stub-ble	Lbs. 96° Sugar Per Ton	Tons Cane Per A.	Lbs. 96° Sugar Per A.
La. Purple	11-17-21	15.6	11.98	76.79	S			
	11- 8-22	15.71	12.43	79.1	P	179.38		
	11-22-22	14.8	11.34	76.6	S			
	11-15-23	14.08	10.27	72.94	P			
	10-22-25	9.65	5.07	52.40	P			
	10-24-25	12.55	8.81	70.20	S			
	10-14-26	12.45	8.20	65.9	S			
	10-25-26	11.50	7.12	61.91	S			
	11- 4-26	12.2	7.75	63.52	S			
	11- 9-26	12.0	7.35	61.25	S			
	11-16-26	12.5	8.43	67.44	S	108.81	25.0	2720
	11-30-26	12.6	8.43	66.90	P	108.1	30.0	3242
Average		12.97	8.93	74.17		133.19		
La. Striped	11- 8-23	12.96	9.8	75.61	P	137.4		
	10-20-25	11.35	7.44	65.50	S			
	10-14-26	11.40	6.71	58.9	S			
	10-25-26	10.90	6.03	55.32	S			
	11- 4-26	12.9	8.48	65.73	S			
	11- 9-26	13.2	9.34	70.76	S	125.0		
	11-16-26	13.1	8.86	67.63	S			
	11-30-26	12.2	7.55	61.88	P			
	12-17-26	14.0	10.35	73.92	P	142.8		
Average		12.44	8.28	66.55		105.6		

TABLE V.—Continued.

Variety	Date	Brix	Suc.	Purity	Plant or Stubble	Lbs. 96° Sugar Per Ton	Tons Cane Per A.	Lbs. 96° Sugar Per A.
D-74	11- 7-21	13.99	8.65	61.83	P			
	11-28-21	14.79	10.49	71.4	S			
	11-10-22	14.56	11.05	76.00	P			
	11-22-22	15.03	11.31	75.2	S			
	11- 6-23	14.08	10.05	71.37	P			
	11-10-24	16.44	11.79	71.10				
	10-17-25	12.99	8.71	67.10	S			
	10-14-25	10.75	6.12	56.9	S			
	12- 4-25	14.8	11.29	76.2	P	158.9		
	10-14-26	11.40	6.89	60.4	S			
	10-29-26	11.6	6.54	56.38	P			
	11- 4-26	12.9	8.61	66.74	S	105.7	22.6	2388
	11-30-26	12.9	9.13	70.77	P			
	12-17-26	12.8	9.11	71.17	P	122.5	29.89	3615
Average		13.45	9.26	68.84		121.4		
DI 52	11-16-26	13.2	8.18	61.96	P			
	11-30-26	12.9	7.98	61.86	P			
Mexican Striped	11- 9-26	12.3	7.70	62.60	S			
Toledo	11-16-26	11.2	3.79	33.83	P			
	11-30-26	11.9	3.82	32.10	P			
Tekcha	11- 9-26	12.3	7.61	61.87	S			
	11-16-26	10.8	4.99	46.20	P			
	11-30-26	10.3	3.88	37.66	P			
Tjepiring 24	11- 9-26	13.0	7.59	58.38	S			
	11-16-26	14.7	10.50	71.42	P			
	11-30-26	13.7	9.76	71.24	P			
Cayana	12- 4-19	15.3	11.61	75.00	P			
	11-19-20	13.37	8.2	61.33				
	11-15-21	13.79	7.17	51.99				
	12- 7-21	16.21	12.08	74.52	P			
	11- 3-22	15.39	11.22	72.9				
	11- 6-23	13.36	8.20	61.38				
	11- 4-25	12.00	7.71	64.30	P			
	11- 4-25	15.00	10.48	69.90	P			
	10-14-26	12.40	7.97	56.20	S			
	10-20-26	10.90	5.85	53.67	P			
	10-25-26	11.80	7.07	59.91	S			
	11- 9-26	11.9	6.58	55.29	S			
	11- 9-26	11.9	6.88	57.82	S			
	11-16-26	13.2	8.45	64.02	S			
	11-30-26	13.0	6.68	51.38	P			
	12- 1-26	11.7	6.68	57.09	P			
	12-17-26	13.0	6.95	53.46	P			

TABLE V.—Continued.

Variety	Date	Brix	Suc.	Purity	Plant or Stub-ble	Lbs. 96° Sugar Per Ton	Tons Cane Per A.	Lbs. 96° Sugar Per A.
Kavangire	11- 9-22	13.61	8.52	62.6				
	11- 6-23	12.97	7.36	56.67				
	11-15-23	13.31	7.52	56.50				
	10-17-25	12.90	8.50	65.40	P			
	11-28-25	15.15	11.14	73.50	P			
	10-14-26	12.25	7.67	62.6	S			
	10-25-26	14.0	10.10	72.14	S			
	10-28-26	10.1	4.98	49.31	P			
	11- 9-26	13.2	8.65	66.53	S			
	11- 9-26	14.5	10.63	73.31	S			
	11-16-26	15.0	10.68	71.20	S			
	11-30-26	11.8	4.80	40.67	P			
	12-17-26	12.0	5.76	48.00	P			
SC 12/4	11-19-15	13.1	8.47	64.5				
	11- 4-16	13.3	8.5	64.6				
	11-20-19	13.6	9.41	69.1				
	11- 9-20	14.34	10.08	70.29				
	11-15-21	15.11	10.70	70.81				
	11-16-21	13.69	8.58	62.67				
	11- 2-22	13.93	9.88	70.9				
	11- 2-22	14.03	10.10	71.9				
	11- 9-22	13.81	9.21	66.6				
	11- 6-23	12.97	9.59	73.98				
	11-15-23	13.54	8.75	64.63				
	11-20-25	11.53	7.57	65.7				
	10-14-26	10.55	5.76	54.6	S			
	10-25-26	12.30	8.00	65.04	S			
	11- 4-26	12.9	8.26	64.3	S			
	11- 9-26	12.1	7.35	60.75	S			
	11-16-26	11.9	7.45	62.60	P	90.19	32.92	2969
	11-16-26	13.2	9.19	69.62	S			
	11-30-26	12.2	6.81	60.80	P			
UBA	11-19-18	13.77	9.41	68.26				
	11- 7-17	14.0	8.04	57.4				
	11-14-21	12.92	6.81	52.71				
	11- 6-23	13.63	7.41	54.36				
	10-17-25	14.60	6.22	42.60				
	10-14-26	11.50	6.23	54.20	S			
	10-28-26	11.2	5.90	52.68	P			
	11- 9-26	10.9	5.48	50.28	S			
	11-30-26	11.8	5.47	46.35	P			
	12-17-26	11.4	4.73	41.49	P			
D-95	10-28-26	13.1	8.21	62.67	P			
	11- 9-26	13.9	10.47	75.32	S			
	12-10-26	12.8	8.78	68.59	P			

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TEST FIELDS

In order to obtain a new and better variety of sugar cane for the State, in a minimum of time and that such variety might be quickly and evenly established throughout the state, a number of test fields were established. These fields are established under an agreement between the American Sugar Cane League, the Office of Sugar Cane Investigations, and the Louisiana State University Sugar Experiment Station. Six of them are in the hands of the latter institution, and are established at Cinclare, Glenwood, Reserve, Sterling, Angola, and Youngsville (F. M. Burley). These fields are in the able hands of Mr. C. B. Gouaux, and the information on the behavior of varieties, as given below, is taken from his reports. There are no tests given for Cinclare. That station was established in the fall of 1926 in place of Raceland, for which it was exchanged with the office of Sugar Investigations. We are deeply indebted to the owners of plantations above mentioned, in their hearty cooperation.

There is considerable difference in the maturity of the respective varieties at these different fields, and therein lies one of the great values of such fields. It stands to reason that a variety that may do well on the river may not necessarily rate the same in the lands around Lafayette; hence it would be dangerous to recommend a cane for the state as a whole on its performance at Baton Rouge alone. This is clearly brought out in the data presented in Table VI.

TABLE VI.

1926 Hand Mill Analyses of Java Seedlings and Checks on Test Field No. 1, Glenwood Plantation, Napoleonville, La.

Seedling Number	Analysis				
	Date	Brix	Suc.	Purity	Age
P. O. J. 36	10-12-26	12.90	8.92	69.10	Stubble
	11-13-26	14.19	10.85	76.40	Plant
	11-13-26	13.90	10.20	73.40	Stubble
P. O. J. 228	10-12-26	12.15	7.88	64.80	Stubble
	11-13-26	13.69	9.88	72.00	Plant
	11-13-26	14.50	11.32	78.00	Stubble

TABLE VI.—Continued.

Seedling Number	Analysis				Age
	Date	Brix	Suc.	Purity	
P. O. J. 234	10-12-26	14.25	10.34	75.50	Plant
	10-12-26	13.55	9.62	70.90	Stubble
	11-13-26	13.93	10.95	78.60	Plant
	11-13-26	13.93	9.86	70.70	Stubble
P. O. J. 826	10-12-26	13.05	8.75	67.00	Stubble
	11-13-26	14.30	10.69	74.60	Plant
	11-13-26	14.03	10.50	74.80	Stubble
J. O. J. 979	10-12-26	12.95	8.28	63.90	Stubble
	11-13-26	14.99	11.22	74.80	Plant
	11-13-26	16.03	12.90	80.40	Stubble
P. O. J. 2379	10-12-26	11.75	6.00	51.10	Stubble
	11-13-26	14.10	9.77	69.20	Plant
	11-13-26	13.93	9.61	68.90	Stubble
D-74	10-12-26	12.50	8.17	65.30	Plant
	10-12-26	12.95	8.92	68.80	Stubble
	11-13-26	14.51	11.56	79.60	Plant
	11-13-26	15.21	12.20	80.20	Stubble
La. Purple	10-12-26	13.25	9.22	69.60	Stubble
	11-13-26	14.71	11.81	80.20	Plant
1926 Hand Mill Analyses of Java Seedlings and Checks on Test Field No. 2, Upper Ten Plantation, Raceland, La.					
P. O. J. 213	10- 9-26	11.30	7.58	65.31	Plant
	11- 4-26	12.97	9.95	76.72	Plant
	11- 4-26	13.20	10.39	78.91	Stubble
P. O. J. 228	10- 9-26	11.71	7.78	66.44	Stubble
	10- 9-26	10.20	5.94	58.13	Plant
	11- 4-26	12.75	9.03	70.82	Plant
	11- 4-26	13.55	10.00	73.80	Stubble
P. O. J 234	10- 9-26	10.13	5.83	57.55	Plant
	10- 9-26	10.53	6.15	58.40	Stubble
P. O. J. 826	10- 9-26	10.33	6.21	60.11	Plant
	10- 9-26	10.59	5.63	53.16	Stubble
	11- 4-26	12.07	8.35	69.18	Plant
	11- 4-26	12.70	8.38	65.99	Stubble
P. O. J. 979	10- 9-26	10.40	6.03	57.98	Plant
	10- 9-26	12.21	7.60	62.22	Stubble
	11- 4-26	12.25	8.08	65.96	Plant
	11- 4-26	14.20	10.88	76.61	Stubble
P. O. J. 2379	10- 9-26	11.10	6.61	59.55	Plant
	10- 9-26	10.23	5.58	54.54	Stubble
	11- 4-26	14.89	11.84	79.73	Plant
	11- 4-26	12.35	8.35	67.63	Stubble
D-74	10- 9-26	10.30	6.21	60.29	Stubble
	11- 4-26	12.85	9.13	71.07	Plant
La. Purple	10- 9-26	8.99	4.40	49.00	Plant
	11- 4-26	11.75	7.93	67.49	Plant

TABLE VI.—Continued.

1926 Hand Mill Analyses of Java Seedlings and Checks on Test Field No. 3, Reserve Plantation, Reserve, La.

Seedling Number	Analysis				Age
	Date	Brix	Suc.	Purity	
P. O. J. 213	10- 1-26	12.30	7.33	59.60	Plant
	10- 6-26	12.00	7.46	62.20	Stubble
	10-28-26	13.90	10.17	73.12	Plant
	10-28-26	13.20	9.68	73.40	Stubble
P. O. J. 228	10- 6-26	10.30	4.84	47.00	Plant
	10- 6-26	11.20	6.67	59.60	Stubble
	10-28-26	13.00	8.87	68.20	Plant
	10-28-26	12.30	7.65	62.20	Stubble
P. O. J. 234	10- 6-26	12.40	7.51	60.60	Plant
	10- 6-26	12.00	6.84	57.00	Stubble
	10-28-26	12.60	9.72	77.20	Plant
	10-28-26	14.30	10.49	73.40	Stubble
P. O. J. 826	10- 6-26	11.90	7.40	62.20	Plant
	10- 6-26	12.20	7.19	59.00	Stubble
	10-28-26	12.90	8.37	69.40	Plant
	10-28-26	12.90	8.51	66.00	Stubble
P. O. J. 979	10- 6-26	12.30	8.51	69.20	Plant
	10- 6-26	12.70	7.23	57.00	Stubble
	10-28-26	15.40	11.36	73.80	Plant
	10-28-26	13.00	8.58	66.00	Stubble
P. O. J. 2379	10- 6-26	12.50	6.90	55.20	Plant
	10- 6-26	11.60	6.12	52.80	Stubble
	10-28-26	12.20	7.73	63.40	Plant
	10-28-26	12.30	7.75	63.00	Stubble
D-74	10- 6-26	12.20	7.39	60.60	Plant
	10- 6-26	12.00	6.93	57.80	Stubble
	10-28-26	12.50	8.65	69.20	Plant
	10-28-26	12.00	7.99	66.60	Stubble
La. Purple	10- 6-26	12.40	7.22	58.20	Plant
	10- 6-26	12.00	6.79	56.60	Stubble
	10-28-26	14.00	10.30	73.60	Plant
	10-28-26	11.90	8.43	66.40	Stubble

1926 Hand Mill Analyses of Java Seedlings and Checks on Test Field No. 5, Youngsville, La.

Seedling Number	Date	Brix	Suc.	Purity	Age
P. O. J. 36	10-16-26	14.50	11.34	78.20	Plant
	10- 1-26	13.70	10.16	74.20	Plant
	11- 3-26	15.00	12.52	83.50	Plant
	11- 5-26	15.28	12.86	84.20	Plant
P. O. J. 213	10- 1-26	12.10	7.22	59.60	Plant
	10-16-26	13.00	9.12	70.10	Plant
	11- 3-26	14.00	11.19	79.80	Plant
	11- 5-26	13.88	11.10	79.90	Plant

TABLE VI.—Continued.

Seedling Number	Analysis				Age
	Date	Brix	Suc.	Purity	
P. O. J. 228	10- 1-26	12.30	7.46	60.60	Plant
	10-16-26	12.90	9.07	70.20	Plant
	11- 3-26	15.45	12.19	78.90	Plant
	11- 5-26	14.94	11.86	79.30	Plant
P. O. J. 234	10- 1-26	15.20	11.45	75.30	Plant
	10- 1-26	16.10	13.06	81.10	Plant
	10-16-26	15.90	13.16	82.80	Plant
	11- 3-26	17.10	14.96	87.50	Plant
	11- 5-26	16.25	13.95	85.90	Plant
P. O. J. 826	11- 3-26	14.45	10.99	76.00	Plant
	11- 5-26	15.23	11.88	77.90	Plant
P. O. J. 979	10- 1-26	13.40	9.15	68.20	Plant
	10-16-26	13.30	8.91	67.00	Plant
	11- 3-26	15.30	11.39	74.40	Plant
	11- 5-26	16.40	12.58	78.40	Plant
La. Purple	10- 1-26	12.80	8.36	65.30	Plant
	10- 1-26	13.00	9.12	70.00	Plant
	10-16-26	14.70	11.58	78.70	Plant
	11- 3-26	15.90	13.15	82.70	Plant
	11- 5-26	14.98	11.70	78.15	Plant

1926 Hand Mill Analyses of Java Seedlings and Checks on Test Field No. 6, State Farm, Angola, La.

P. O. J. 36	10-15-26	10.30	6.58	63.80	Stubble
	10-15-26	11.90	7.95	67.70	Plant
	11-19-26	12.00	7.49	62.41	Stubble
	11-19-26	12.60	6.65	52.81	Stubble
P. O. J. 213	10-15-26	11.40	6.73	59.00	Stubble
	11-19-26	14.30	10.61	74.22	Stubble
P. O. J. 228	10-15-26	11.60	7.47	64.40	Plant
	10-15-26	12.80	8.53	66.70	Stubble
	11-19-26	14.70	10.99	74.75	Stubble
	11-19-26	14.20	9.90	69.75	Stubble
P. O. J. 234	10-15-26	13.60	9.19	67.70	Plant
	10-15-26	13.30	9.39	70.70	Stubble
	11-19-26	13.30	8.39	63.06	Stubble
P. O. J. 826	10-15-26	11.10	7.23	65.20	Stubble
	11-19-26	13.90	10.33	74.35	Stubble
P. O. J. 979	10-15-26	12.40	7.80	62.80	Stubble
	10-15-26	12.10	7.80	64.50	Plant
	11-19-26	13.20	7.87	59.64	Stubble

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TABLE VI.—Continued.

Seedling Number	Analysis Date	Brix	Suc.	Purity	Age
P. O. J. 2379	10-15-26	12.10	6.90	57.00	Plant
	11-19-26	13.90	9.25	66.56	Stubble
D-74	10-15-26	12.40	7.68	61.80	Plant
	10-15-26	10.80	8.73	80.70	Stubble
	11-19-26	13.70	9.53	69.57	Stubble
La. Purple	10-15-26	12.70	8.92	70.20	Stubble
	10-15-26	13.20	9.39	70.70	Plant
	11-19-26	14.40	11.39	79.13	Stubble

If we should average the analysis of each of these canes as they show at the six test fields, we might say that we would get a set of figures that would represent something like average weather conditions. While the soil is different and would have its influence, we still have the average by comparison of canes grown under extreme rainfall at Raceland and Sterling, and effect of drought at Youngsville.

Table VII. shows an average of the different varieties at these fields and may be of some value.

TABLE VII.

Average of 1926 Analyses from all Test Fields on Java Seedlings and Checks.

Seedling Number	No. of Ana.	Brix	Sucrose	Purity	Lbs. 96° Sugar Per Ton
P. O. J. 234	18	13.79	10.05	72.87	137.56
P. O. J. 36	11	13.29	9.59	72.15	130.34
La. Purple	16	13.16	9.35	71.05	125.70
P. O. J. 979*	18	13.47	9.23	68.52	120.73
P. O. J. 213	12	12.88	9.11	70.72	120.24
P. O. J. 228	19	12.85	8.90	69.26	117.40
D-74*	13	12.60	8.70	69.05	114.40
P. O. J. 826	15	12.77	8.69	68.05	113.07
P. O. J. 2379	13	12.53	7.87	62.81	95.67

*Stalks with broken tops not included in above tests.

MILL TESTS

There has been some uneasiness on the part of mill owners as to their ability to handle P. O. J. canes with their present equipment, and also as to the commercial returns that they could get from these canes. In order to throw some light on that subject mill tests were run at Glenwood and at Reserve, with the following results:

TABLE VIII.

Glenwood Mill Test—November 22, 1926.

Variety	Juice	Brix	Sucrose	Purity
P. O. J. 228	Crusher	13.96	10.03	71.8
	Mixed	13.47	9.34	69.6
	Residual	13.33	8.51	63.8
P. O. J. 36	Crusher	13.25	9.51	71.07
	Mixed	13.30	9.34	70.02
	Residual	13.19	8.56	64.90
P. O. J. 234	Crusher	14.53	11.58	79.6
	Mixed	14.59	11.34	77.7
	Residual	14.63	10.55	72.1
P. O. J. 826	Crusher	13.85	9.88	71.3
	Mixed	13.71	9.47	69.07
	Residual	13.53	8.65	63.93
P. O. J. 2379	Crusher	13.05	8.23	63.06
	Mixed	12.87	8.13	63.2
	Residual	12.93	7.91	61.2
Cayana 10	Crusher	13.05	8.58	65.7
	Mixed	13.37	8.57	64.0
	Residual	13.43	7.85	58.4
*D-74	Crusher	13.07	9.70	74.2
	Mixed	13.24	9.84	74.3
	Residual	12.99	9.08	69.9
Native Dry	Crusher	13.26	9.81	74.1
	Mixed	13.07	9.77	74.5
	Residual	12.7	9.24	72.8
Native Wet	Crusher	12.83	9.40	73.2
	Mixed	12.17	8.94	73.5
	Residual	8.63	5.8	67.2
*P. O. J. 979	Crusher	13.43	9.36	69.6
	Mixed	13.6	9.34	66.3
	Residual	14.03	9.62	68.6

*Large percentage of storm broken stalks in the cane milled—both D-74 and P. O. J. 979.

Variety	Bagasse % Water	% Fiber	Tons of Cane in Test	Available Suc. Per Ton Cane
P. O. J. 228	45.6	49.7	3.85	119.4
P. O. J. 36	52.67	32.48	2.56	119.1
P. O. J. 234	55.8	38.6	3.72	154.1
P. O. J. 828	51.08	44.55	2.68	119.9
P. O. J. 979	60.72	34.52	1.36	110.5

P. O. J. 2379	60.3	35.75	1.66	95.6
Cayana 10	44.74	50.06	4.83	101.7
D-74	55.8	39.05	4.58	131.0
Native	--------	--------	--------	129.7

Note: Bagasse necessarily brought to Baton Rouge for analysis, and fermentation set in before sucrose could be determined.

TABLE IX.

Reserve Mill Test—Godchaux Sugars, Inc.—November 27, 1926.

Variety	Juice	Brix	Sucrose	Purity	Glucose	Acidity
P. O. J. 234	Crusher	15.57	12.27	78.81	1.3	1.1
	Mixed	14.63	11.93	75.39	1.6	1.4
	Residual	13.69	9.45	69.03	1.6	1.9
P. O. J. 228	Crusher	14.47	10.37	71.66	1.4	.9
	Mixed	14.32	10.10	70.53	1.6	1.2
	Residual	13.99	9.12	65.69	1.7	2.3
P. O. J. 213	Crusher	15.69	11.27	71.83	1.8	.9
	Mixed	15.34	10.18	66.36	1.9	1.2
	Residual	15.09	9.12	60.44	2.3	1.9
La. Purple	Crusher	14.63	10.97	74.98	1.5	.6
	Mixed	14.43	10.54	73.04	1.6	.9
	Residual	14.34	9.76	68.06	1.7	1.6

Bagasse Analyses.

Variety	% Bagasse	Sucrose	Moisture	Fiber
P. O. J. 234	30.89	3.84	48.5	14.19
P. O. J. 228	27.97	3.70	48.0	12.97
P. O. J. 213	34.05	3.70	47.0	15.96
La. Purple	26.70	3.98	48.8	12.11

Available Sucrose Yields.

Variety	Cane Lbs.	Weight Juice Lbs.	Juice Lbs. Per Ton	Extraction	Avail. Sugar	
					Ton	Acre
P. O. J. 234	5940	4105	1382.15	69.11	129.9	2143
P. O. J. 228	9440	6800	1440.68	72.03	118.76	2002.3
P. O. J. 213	3980	2625	1319.09	65.05	104.9	1490.6
La. Purple	8520	6245	1465.96	73.3	129.07	1409.4

Note: Sucrose calculated on extraction shown by each variety, and B. H. E. of 98, using Java formula. No maceration used on mills. Fiber determined by calculation.

The mill tests at Reserve were conducted under the supervision of Mr. J. P. Grevens, manager of Reserve Factory, and Mr. F. J. Gayle, Chief Chemist.

The Experiment Station wishes to express appreciation of the efforts on the part of the owners and their staffs of these two factories for the hearty cooperation in making these tests.

In conclusion, there is a tendency on the part of quite a number of planters to expect too much of the new varieties. The Experiment Station firmly believes that the new varieties are going to be a great factor in relieving the depressed condition of our industry, but we do not believe that any variety is capable of doing it all. It is well known that good drainage, thorough preparation of the soil and good and proper cultivation are necessary for the successful growing of any crop, and that such practice can not be over-emphasized when sugar cane on a Louisiana plantation is the crop under consideration. A reduced acreage properly cared for is preferable to a full acreage which, by necessity, has not received that attention.

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